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(12) **United States Patent**
Schneider

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(54) **LAMINATED WIRE CONNECTOR**

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(73) Assignee: **Interplex Industries, Inc.**, East Providence, RI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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Related U.S. Application Data

(60) Provisional application No. 62/803,203, filed on Feb. 8, 2019, provisional application No. 62/690,408, filed on Jun. 27, 2018.

(51) **Int. Cl.**
H01R 4/24 (2018.01)
H01R 4/2429 (2018.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01R 4/2429*** (2013.01); ***H01R 4/2425*** (2013.01); ***H01R 9/226*** (2013.01); ***H01R 12/585*** (2013.01); ***H01R 13/41*** (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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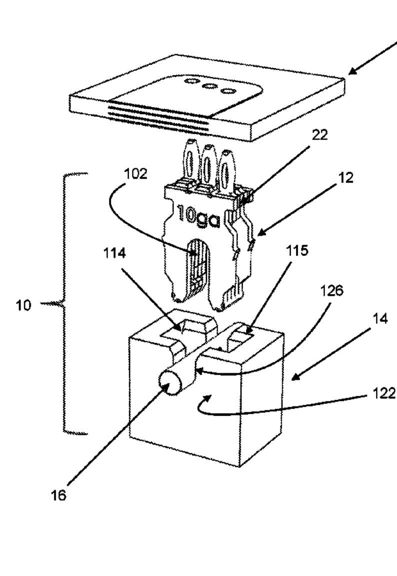
Primary Examiner — Ross N Gushi
(74) *Attorney, Agent, or Firm* — Katterle Nupp LLC; Paul Katterle; Robert Nupp

(57) **ABSTRACT**

An electrical connector and associated terminal are disclosed for making an electrical connection to a wire. The terminal includes a plurality of metal plates adjoining each other to form a stack that defines a passage for receiving the wire. The plates include a plurality of cutter plates disposed between a pair of outer holding plates. Each of the cutter plates has a pair of cutting edges for disrupting any insulation on the wire to permit a conductor of the wire to directly contact the cutter plate. One or more of the cutter plates may have a contact projection for making an electrical connection. The connector includes the terminal and may further include a housing. The holding plates of the terminal have outer edges with abutment features for engaging interior surfaces of the housing.

21 Claims, 42 Drawing Sheets



(51) **Int. Cl.**

H01R 12/58	(2011.01)
H01R 13/41	(2006.01)
H01R 9/22	(2006.01)
H01R 4/2425	(2018.01)

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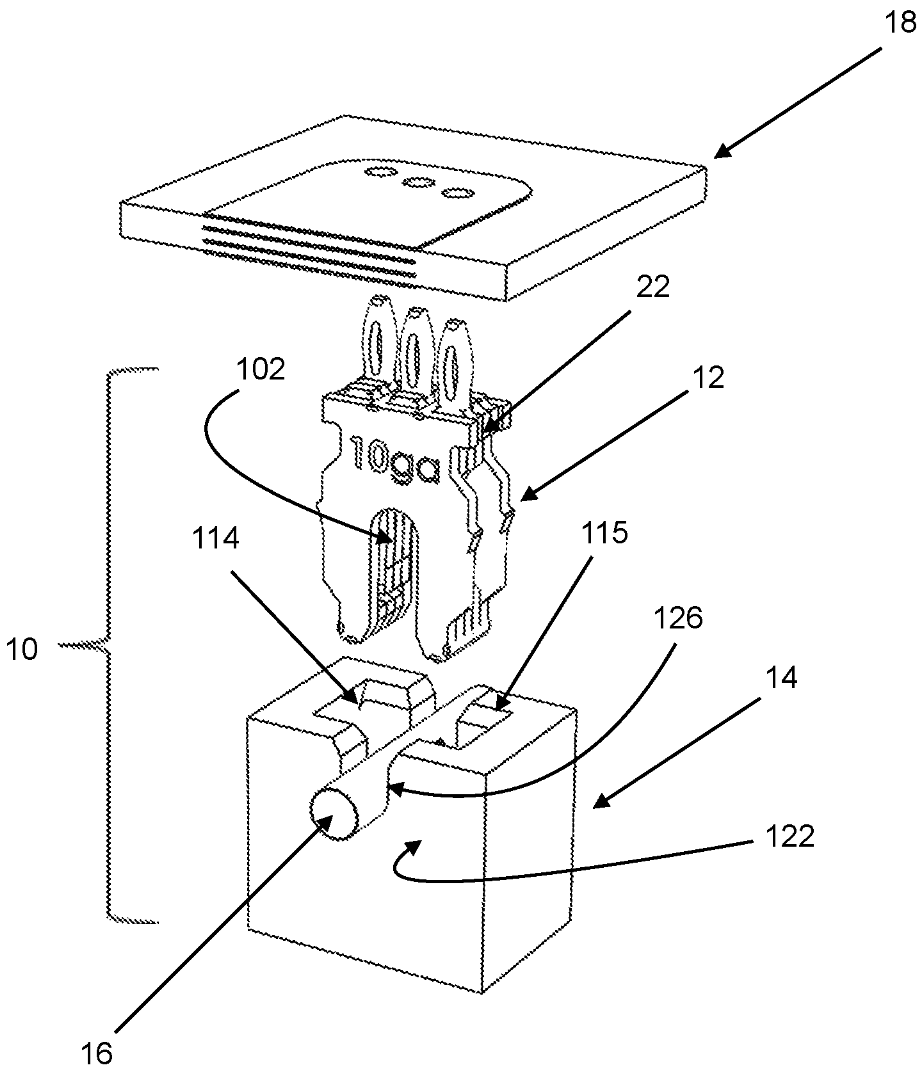

FIG. 1

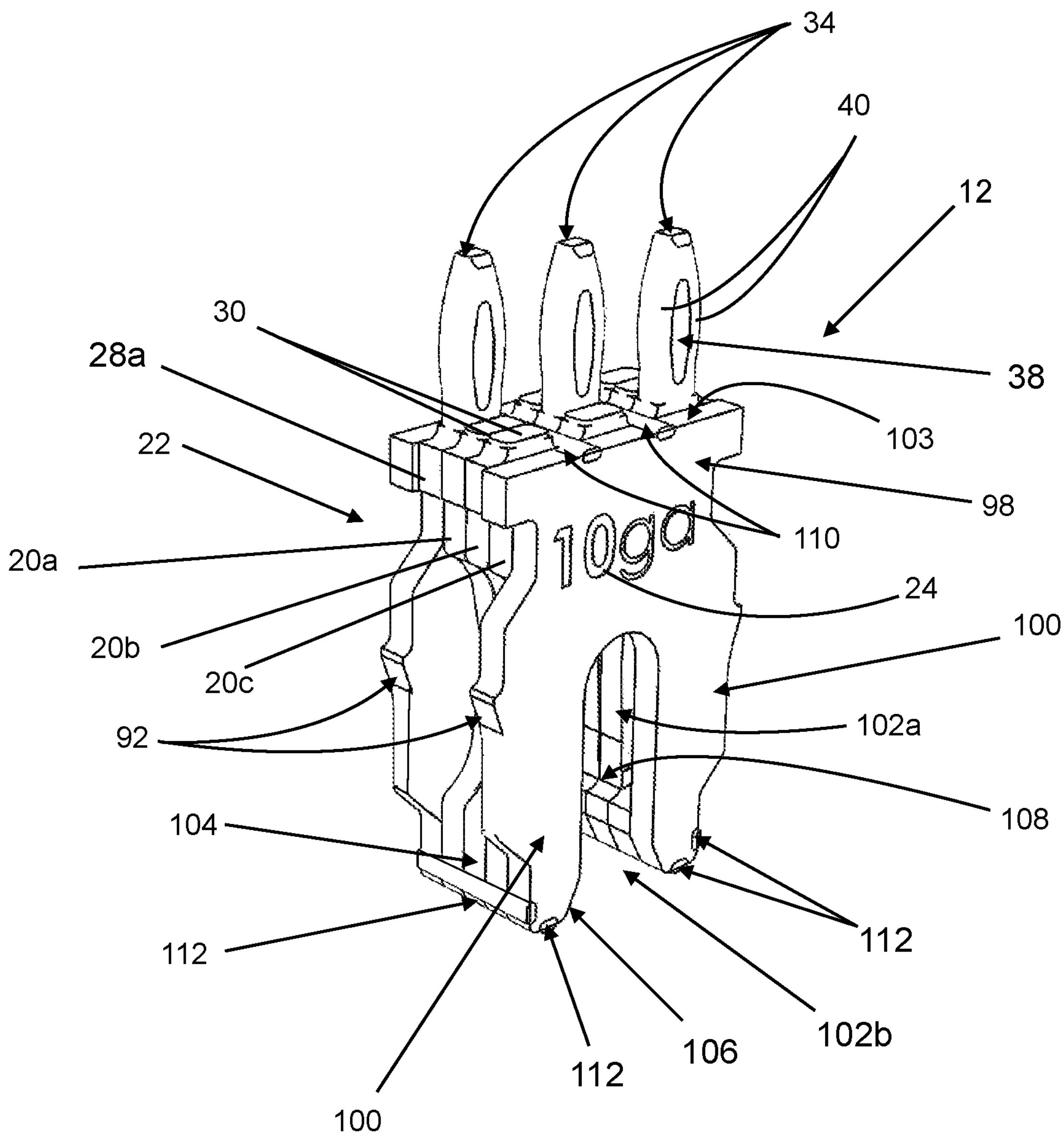
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FIG. 2

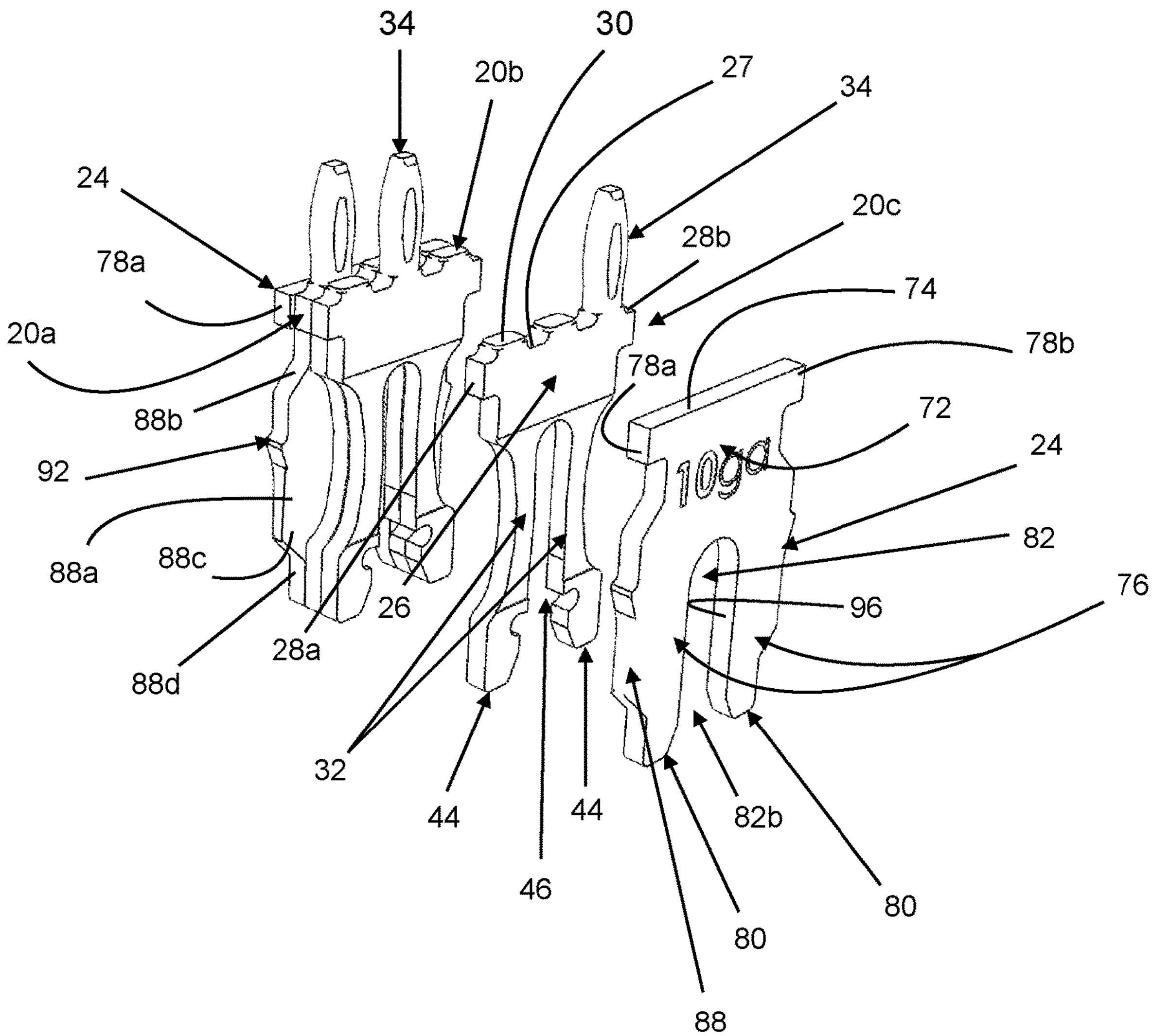
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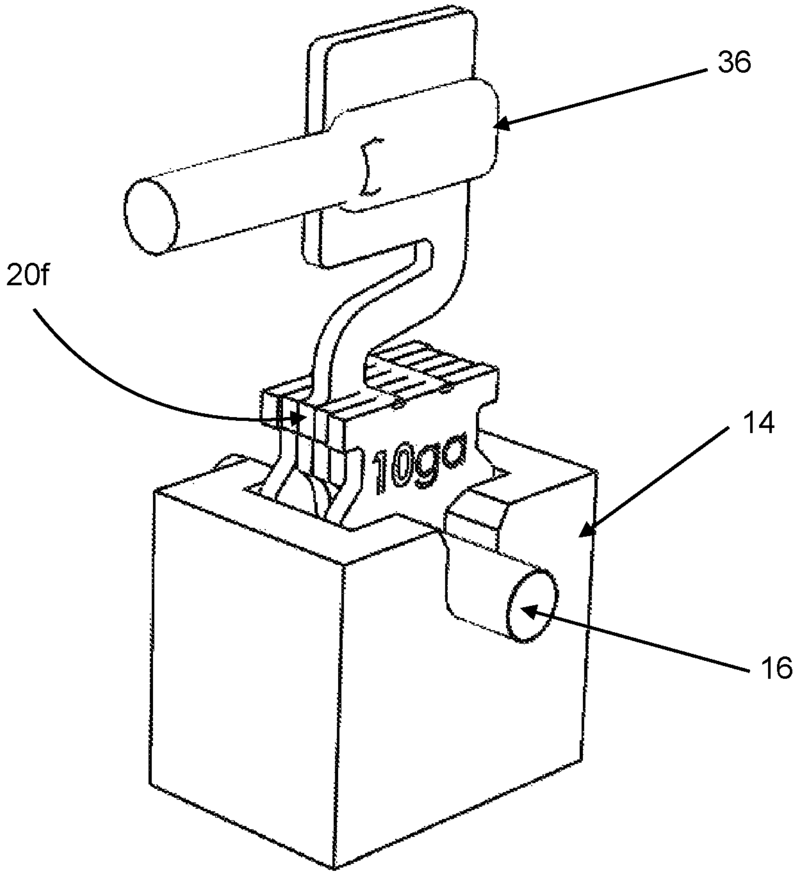
FIG. 3



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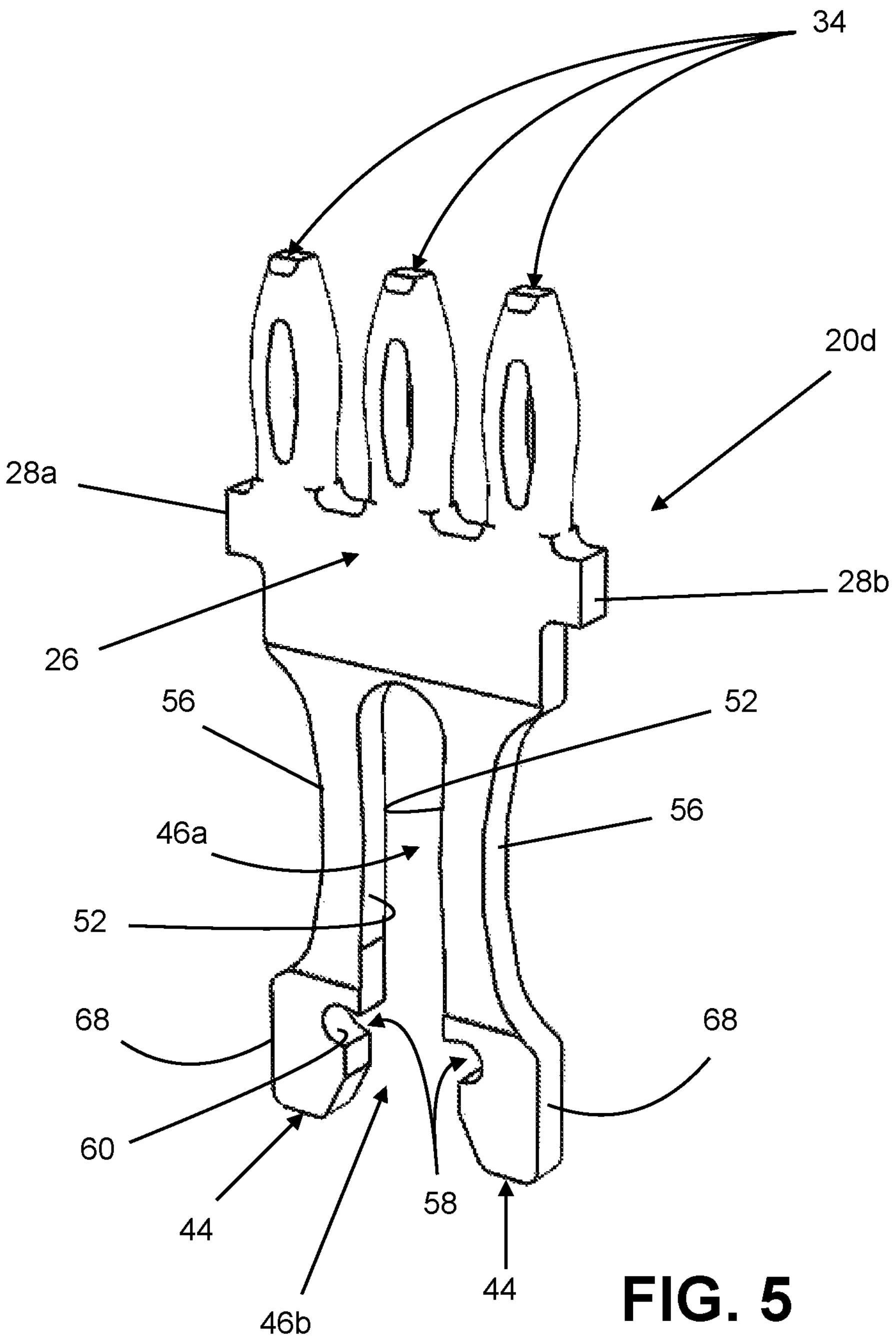

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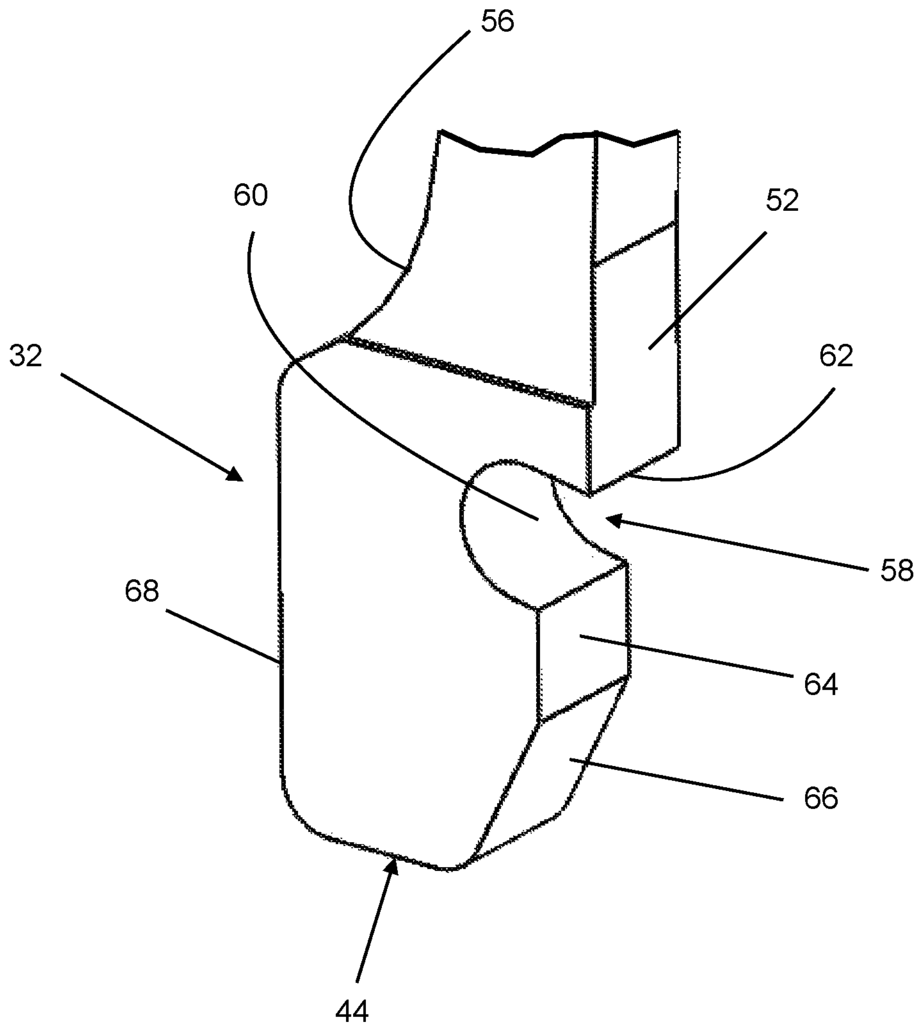

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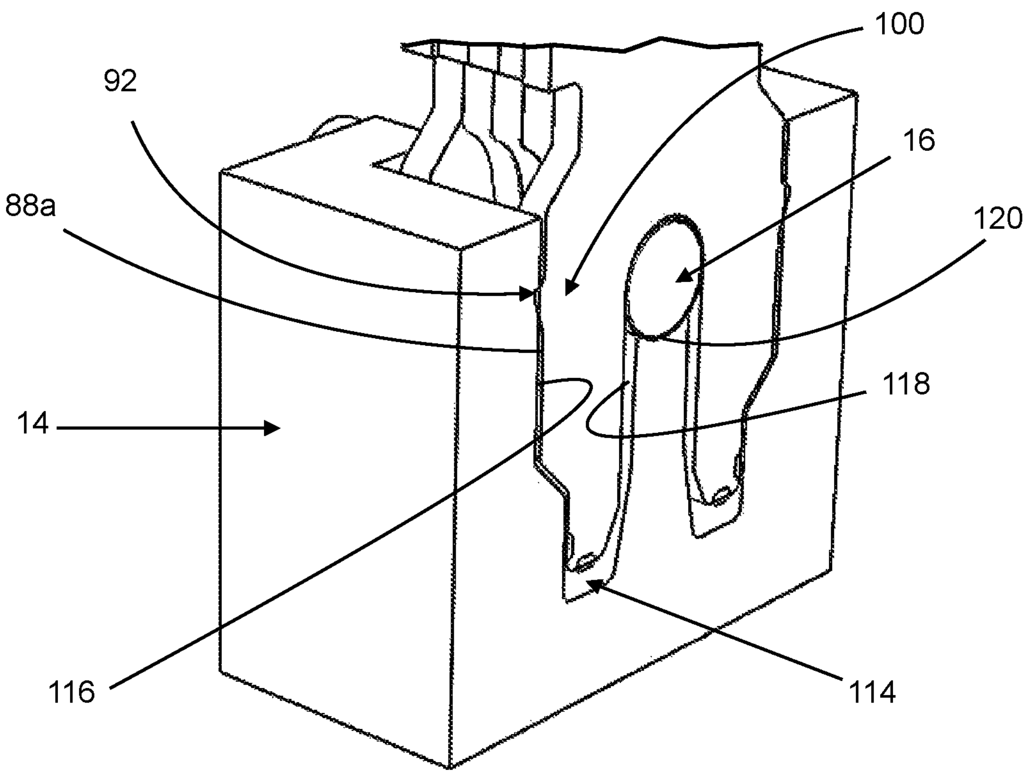
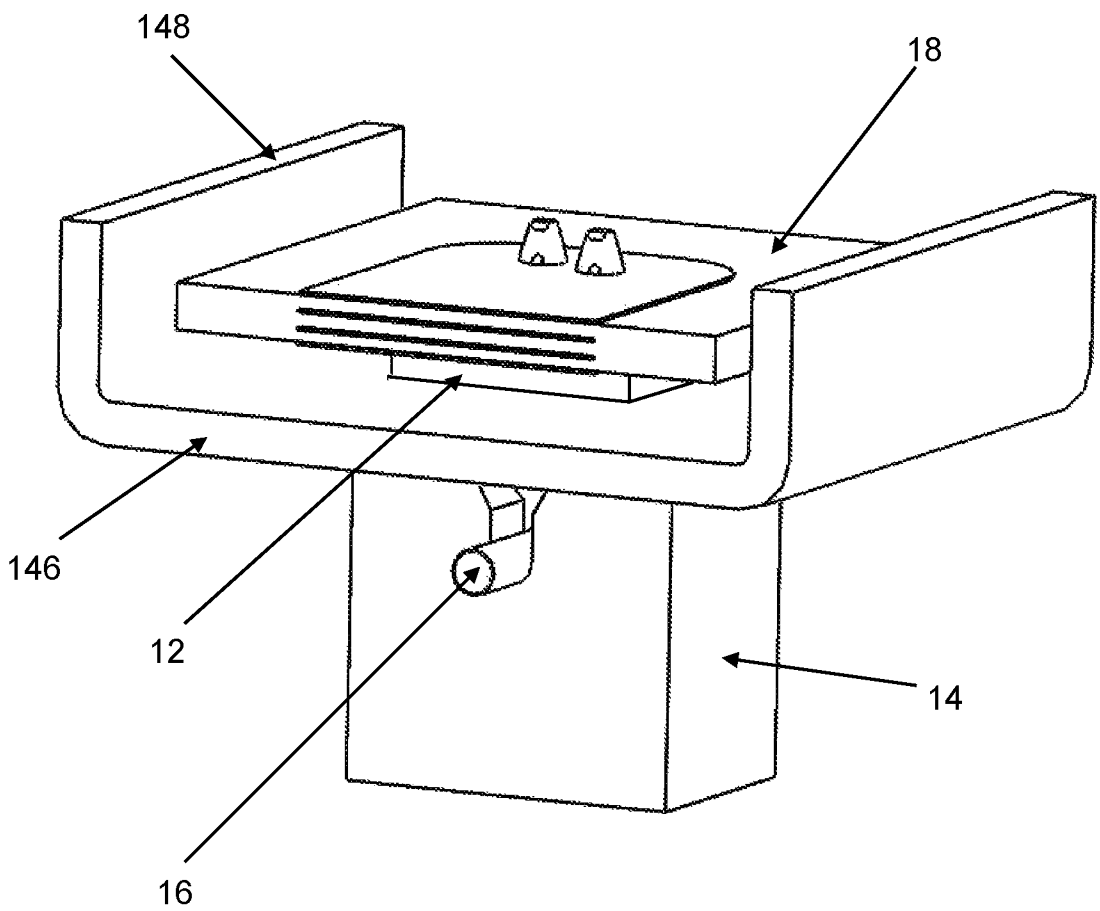


FIG. 7



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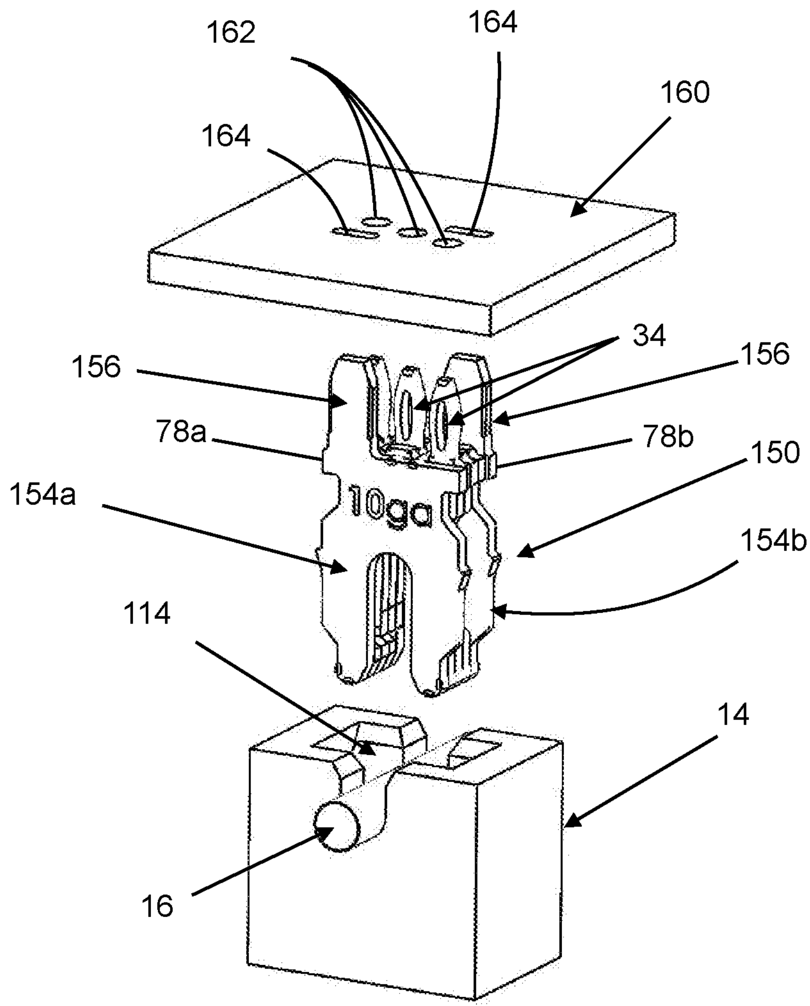

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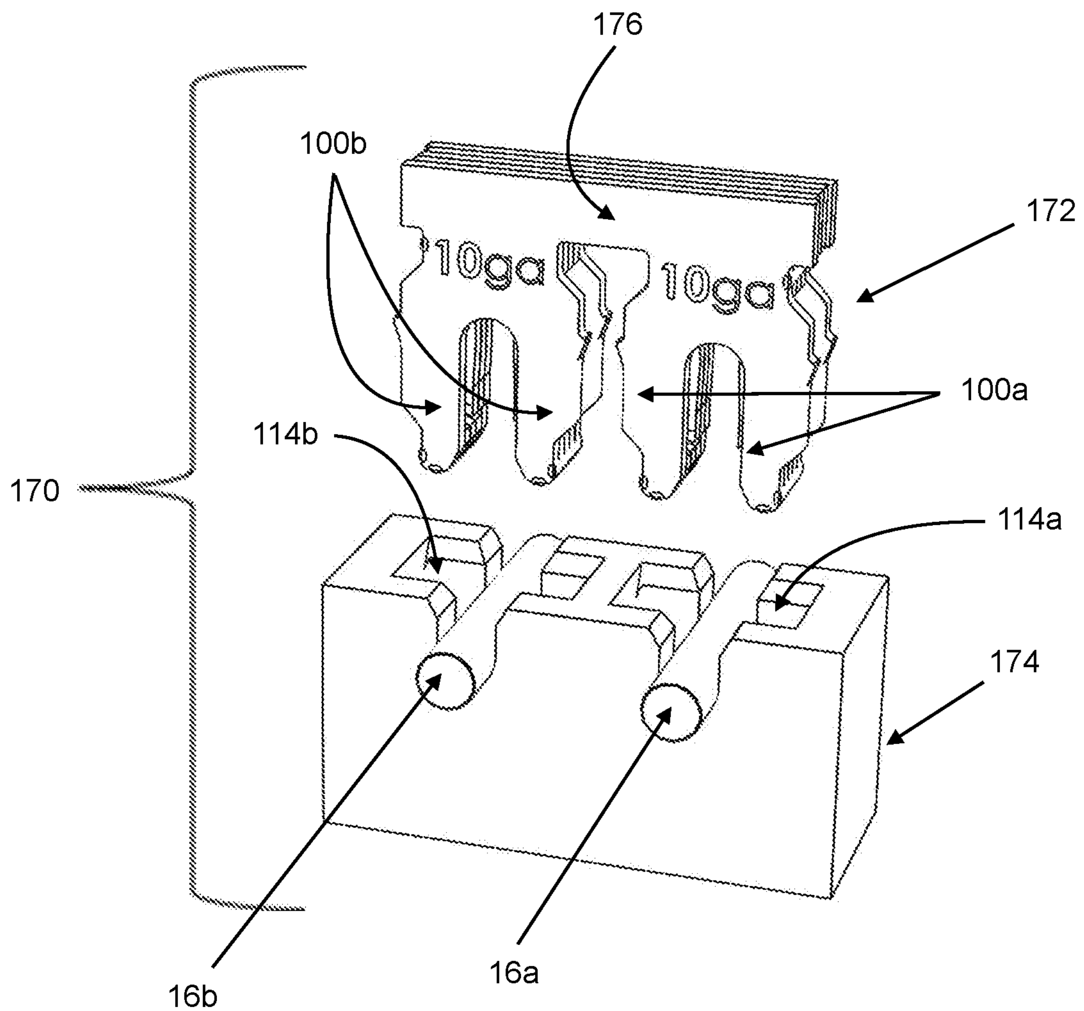

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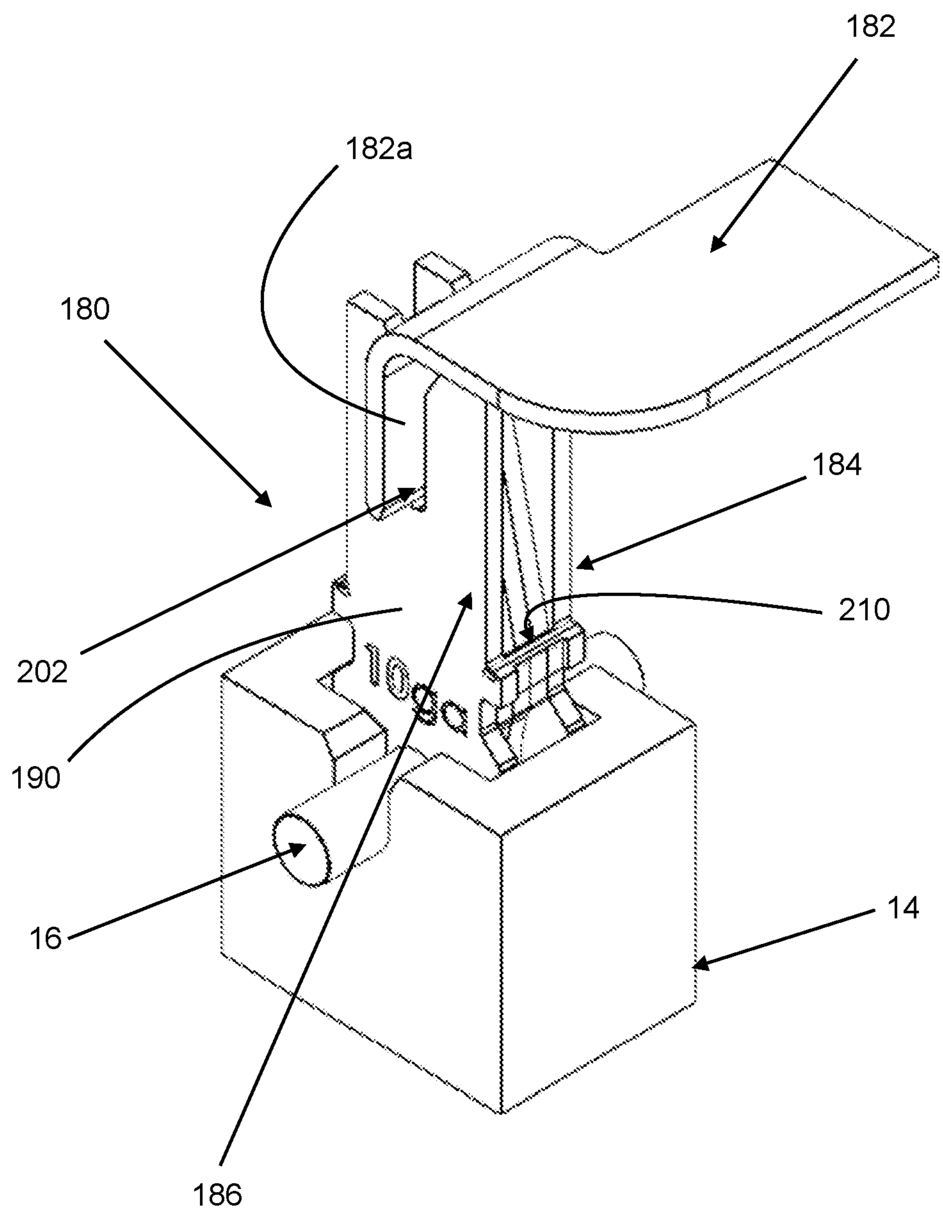

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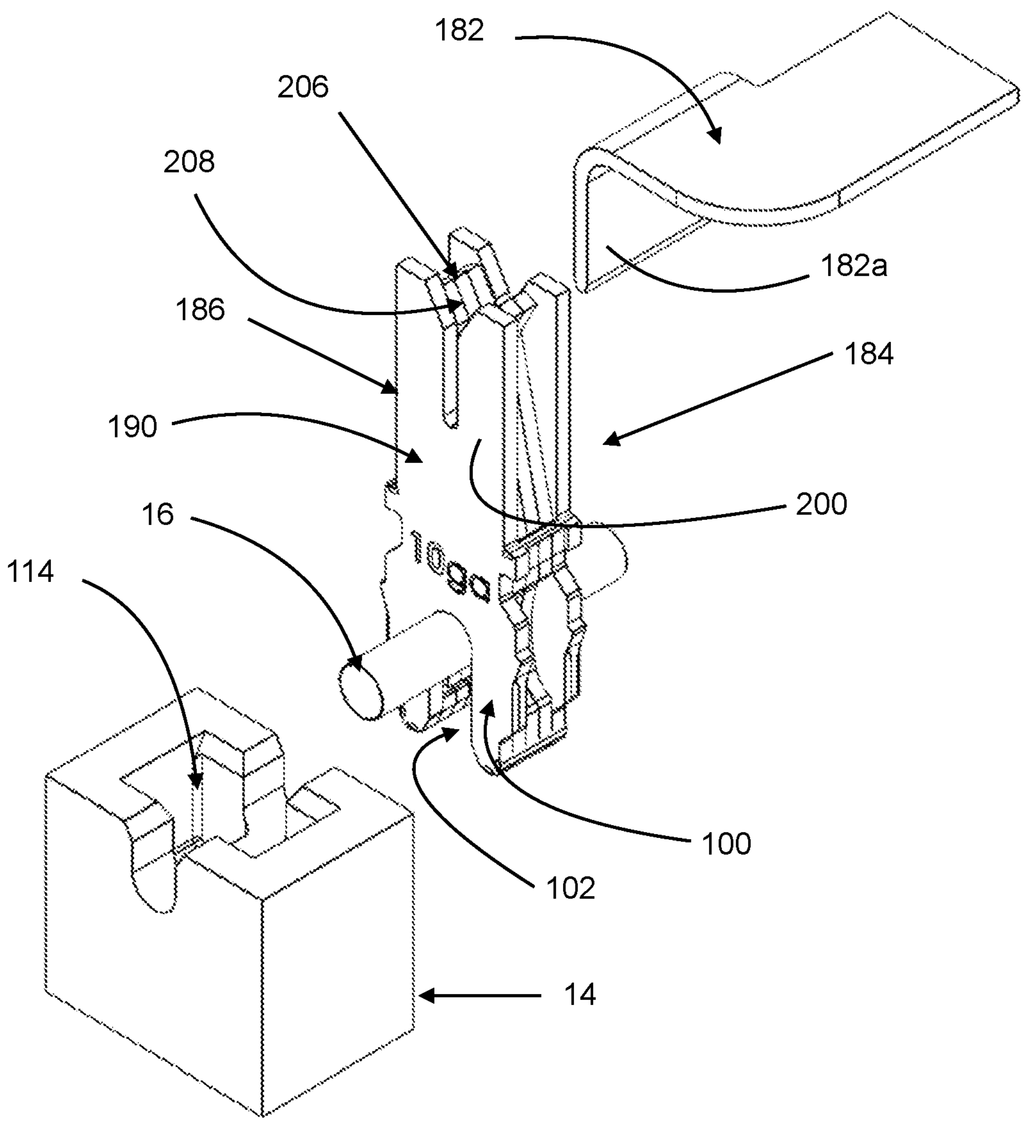

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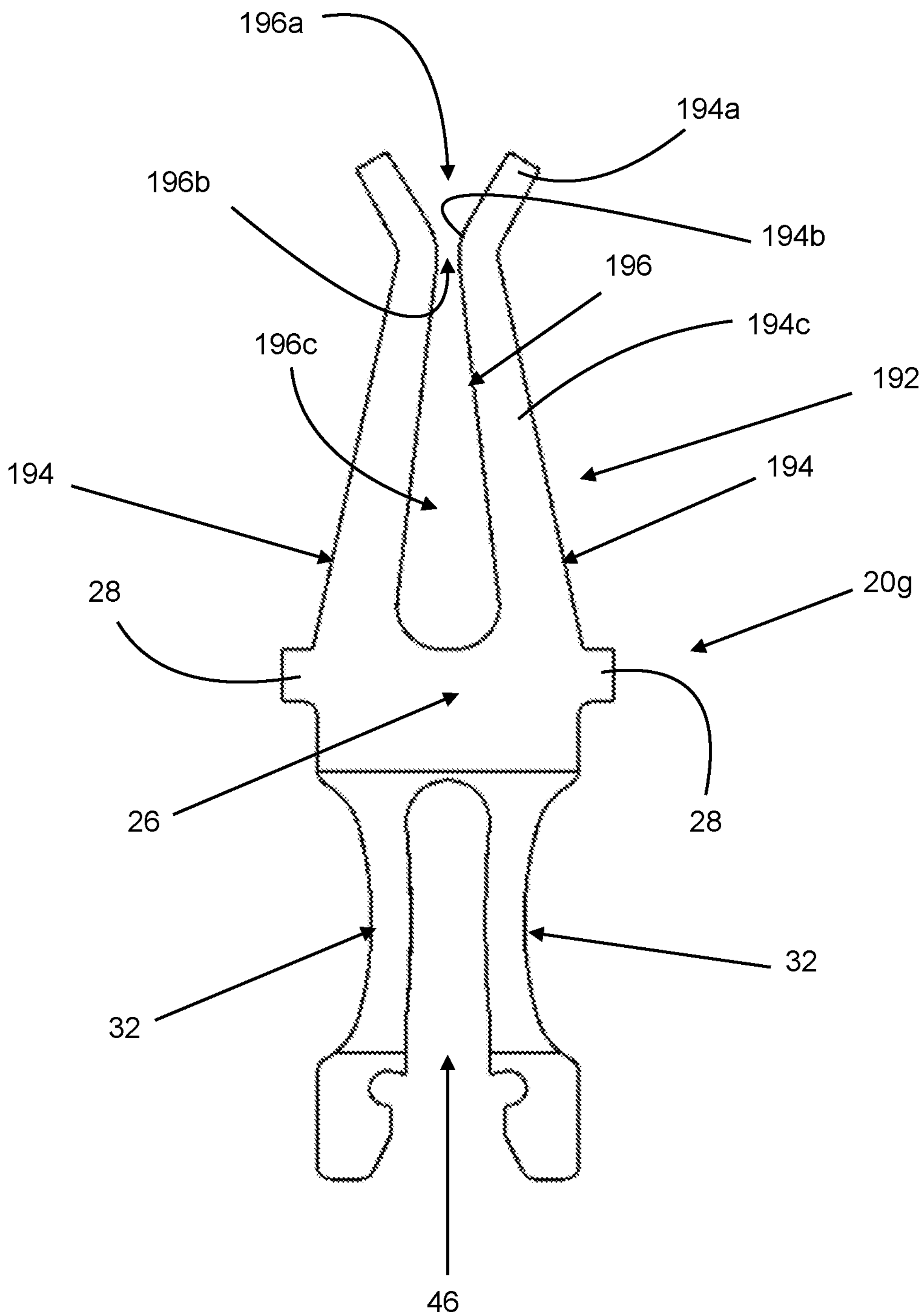
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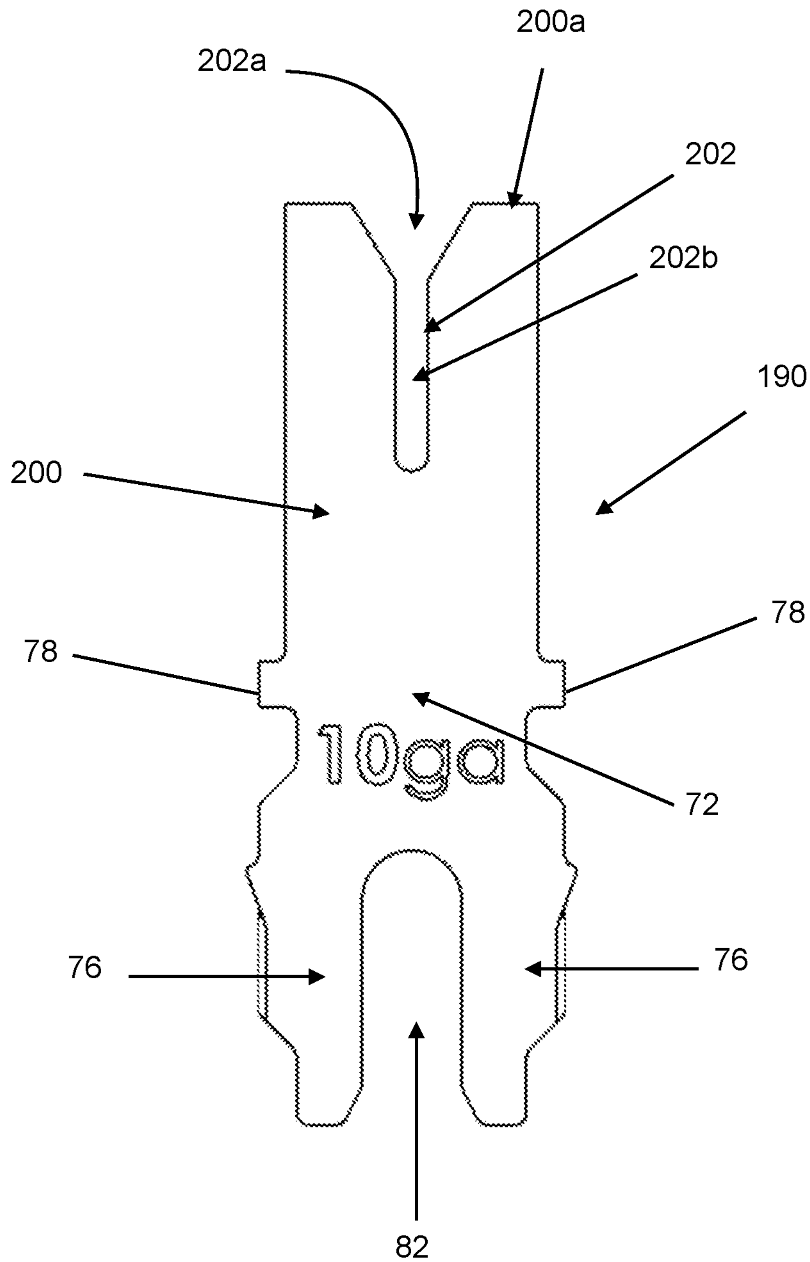
FIG. 13



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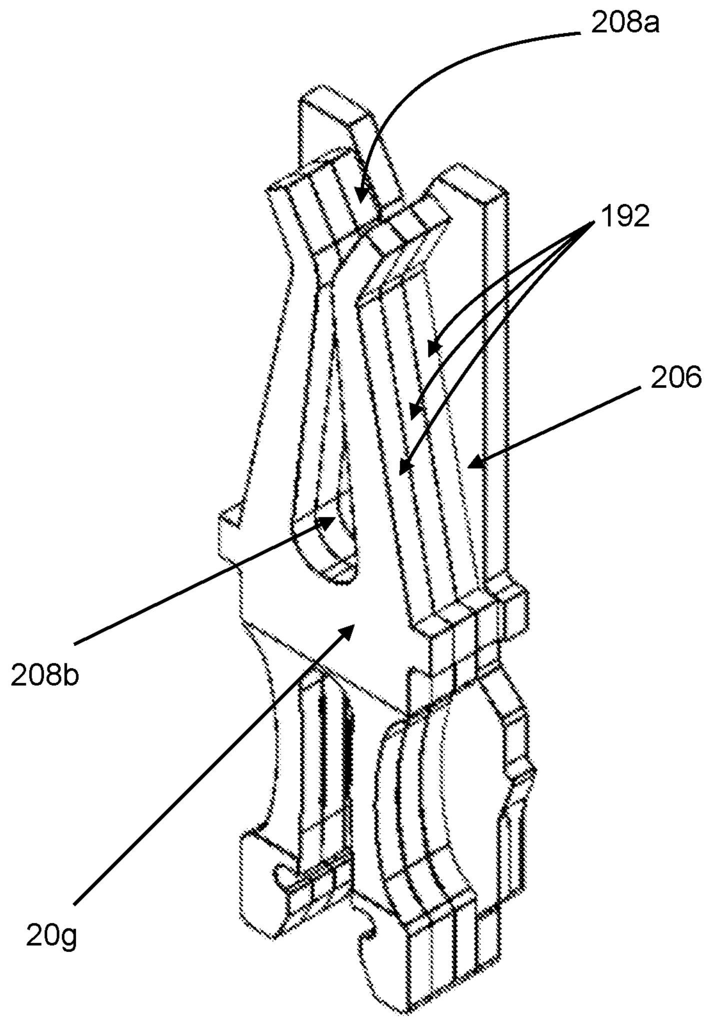

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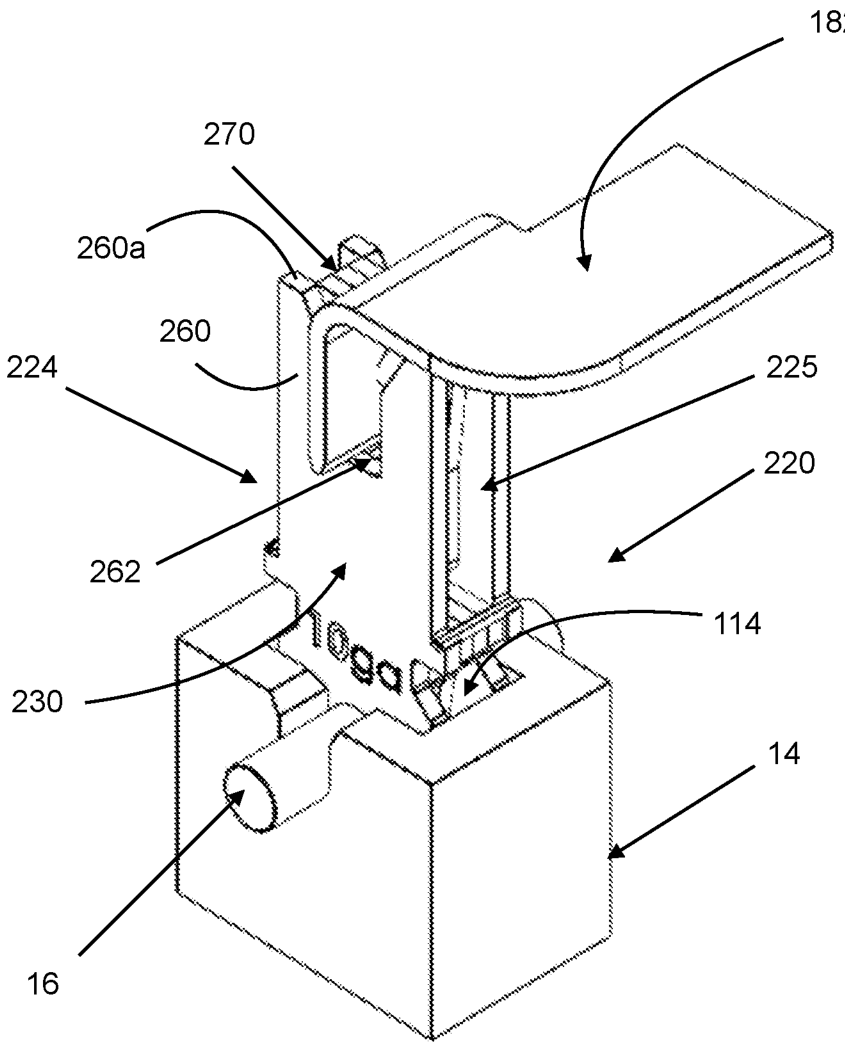

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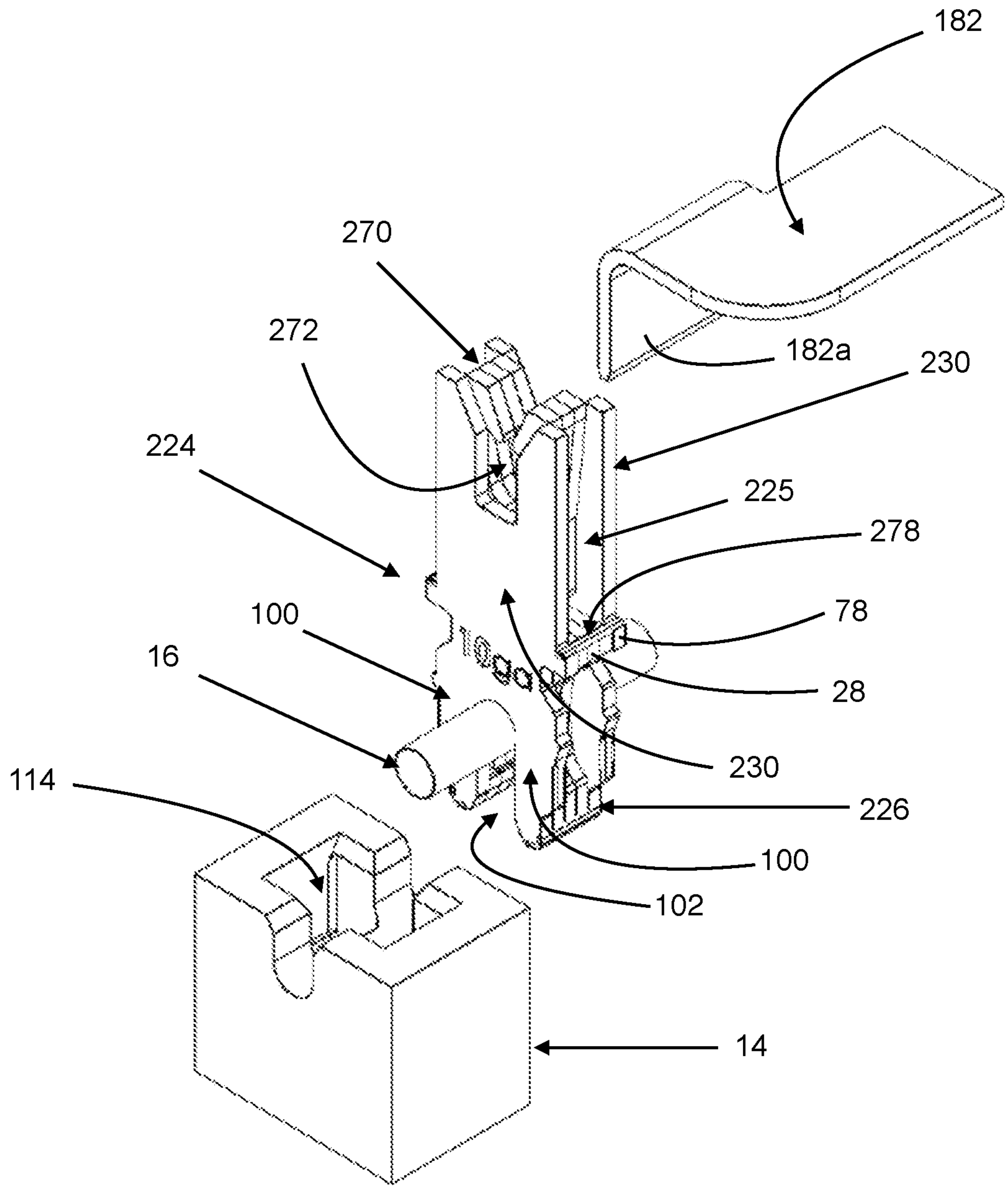
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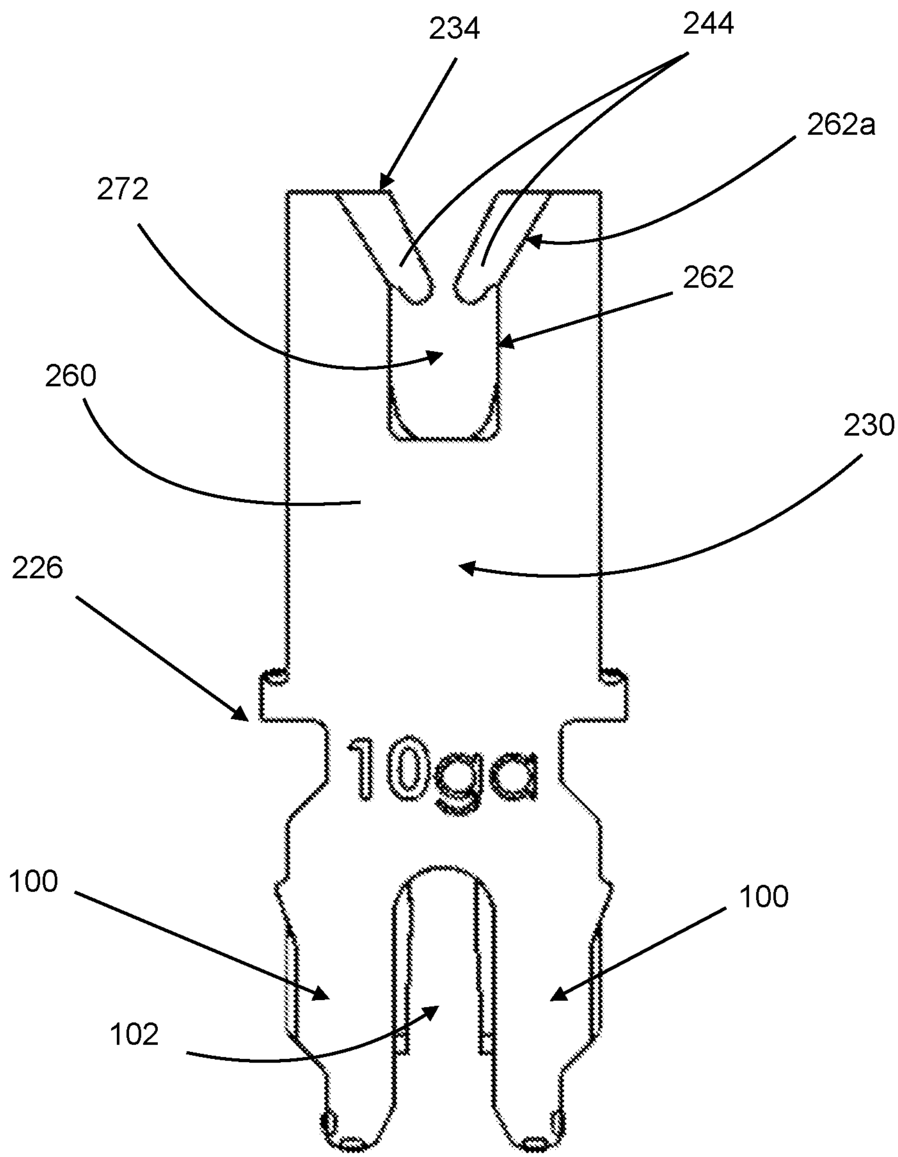
FIG. 17



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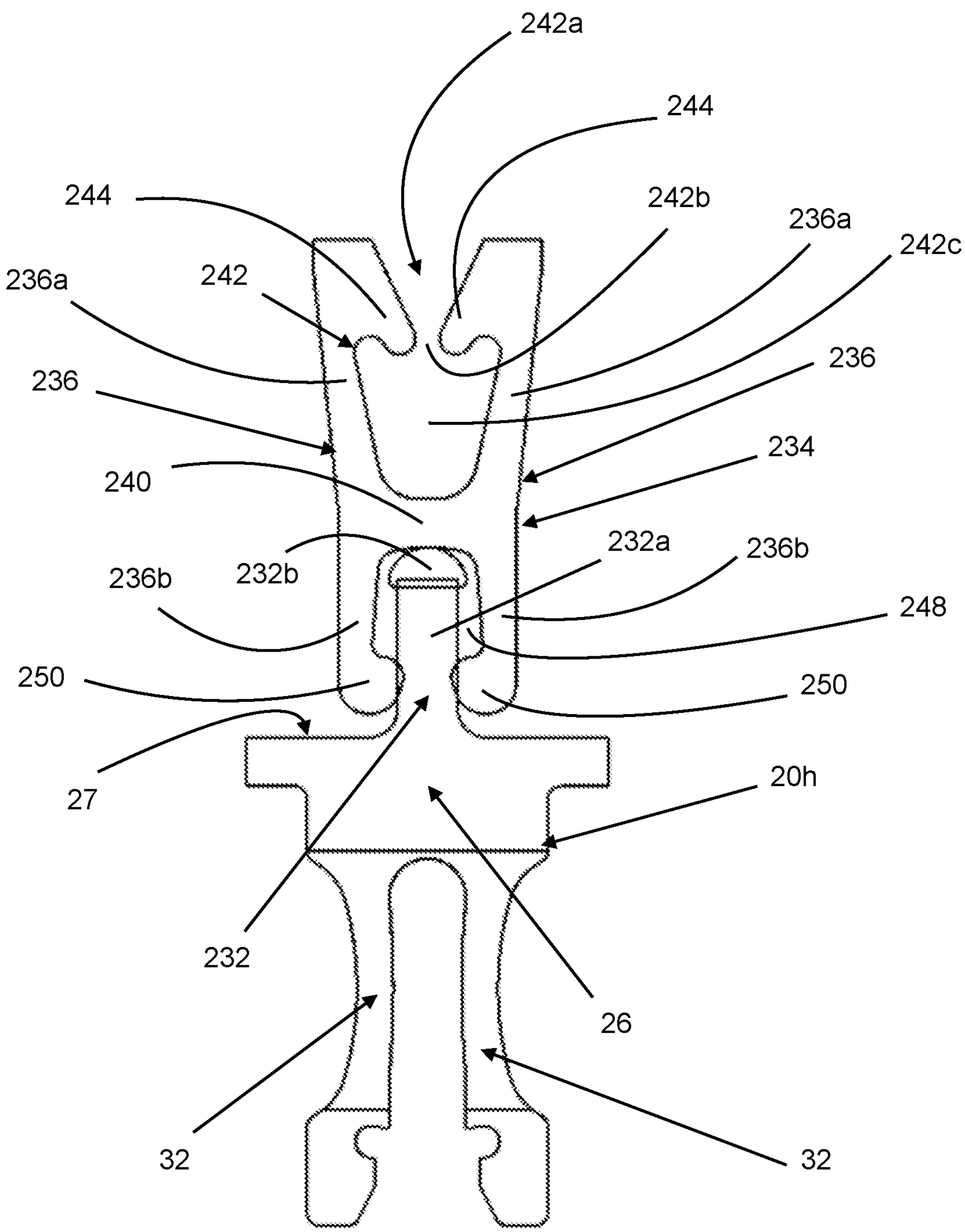
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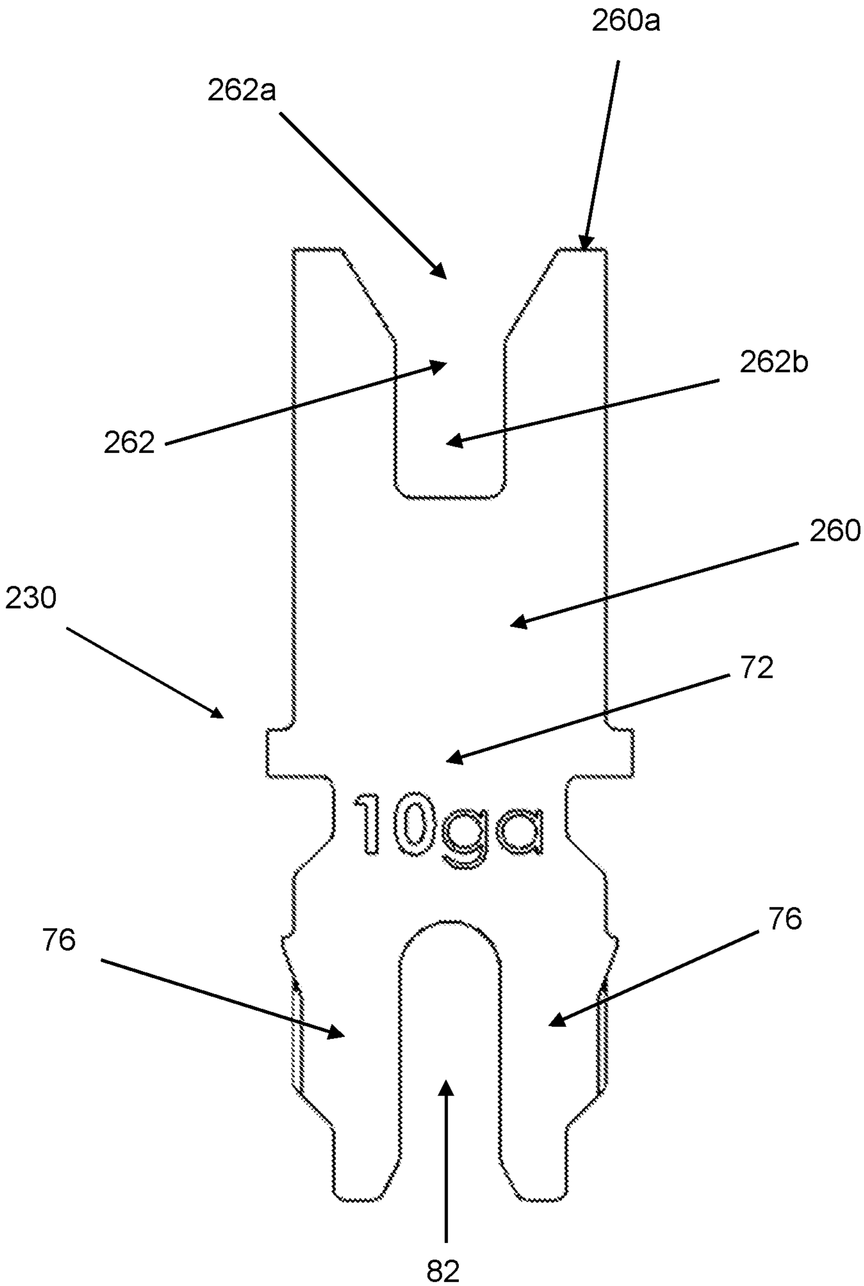
FIG. 19



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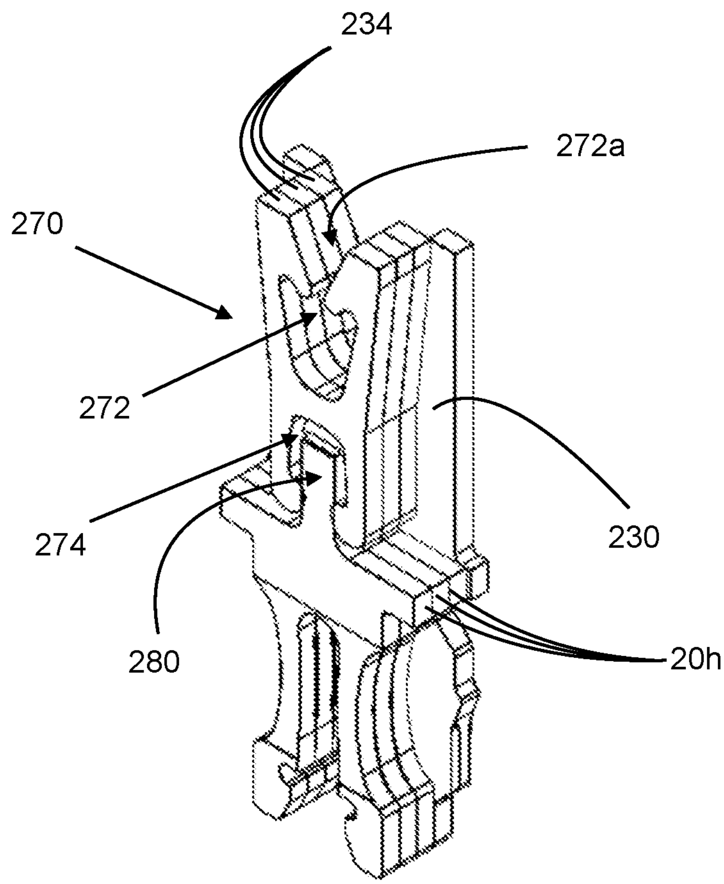

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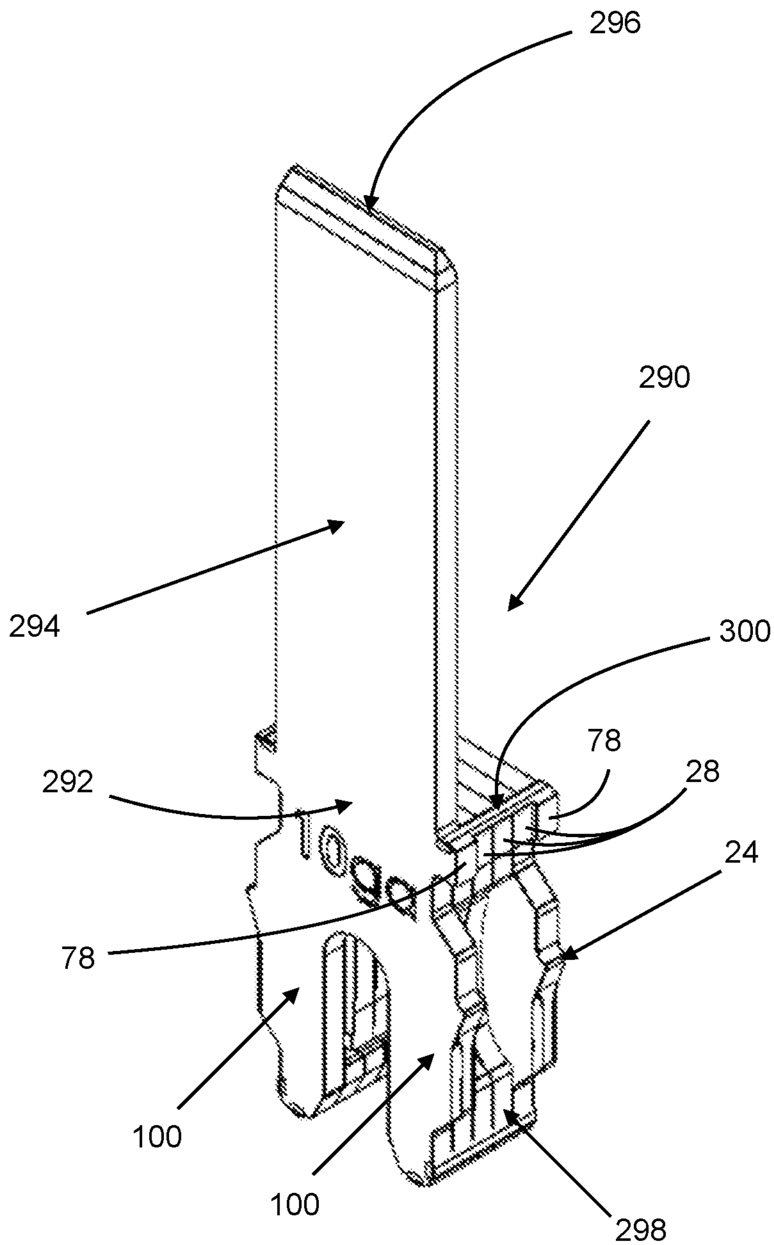

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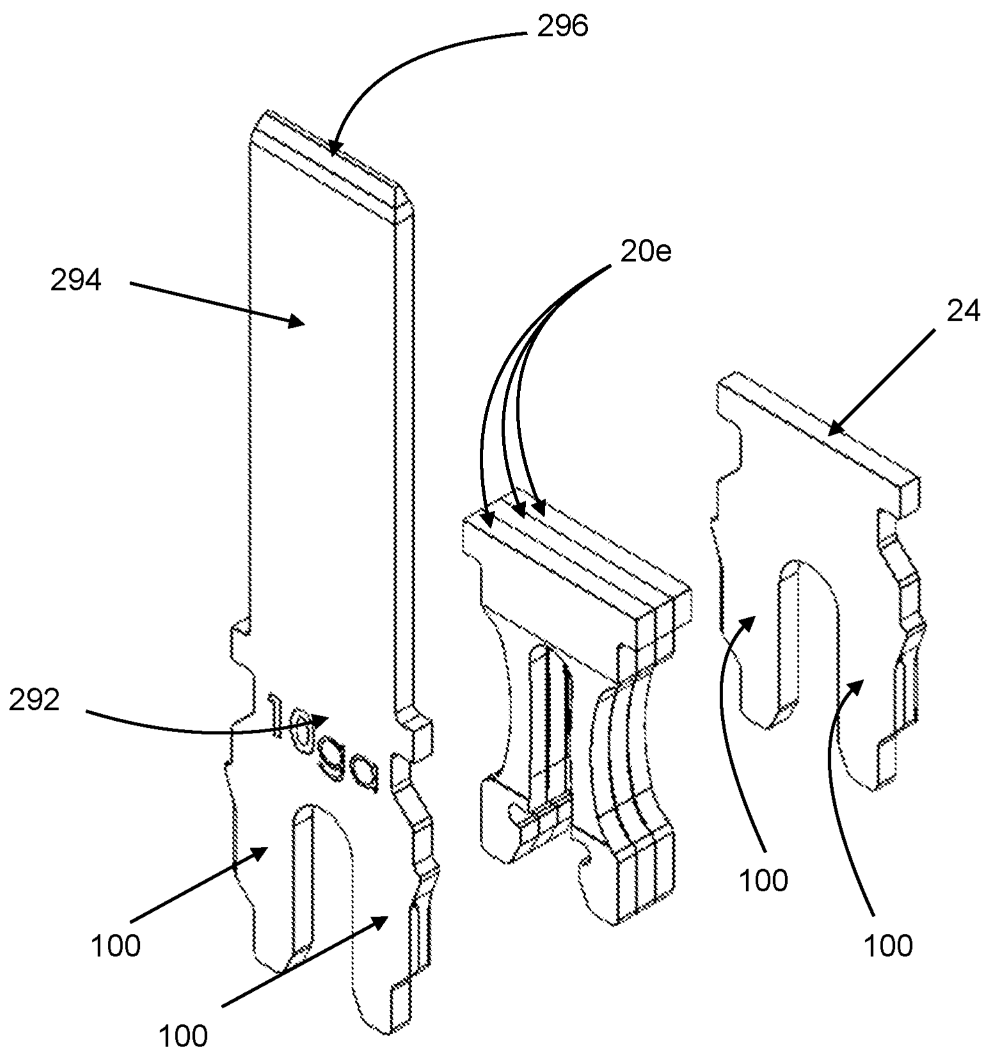

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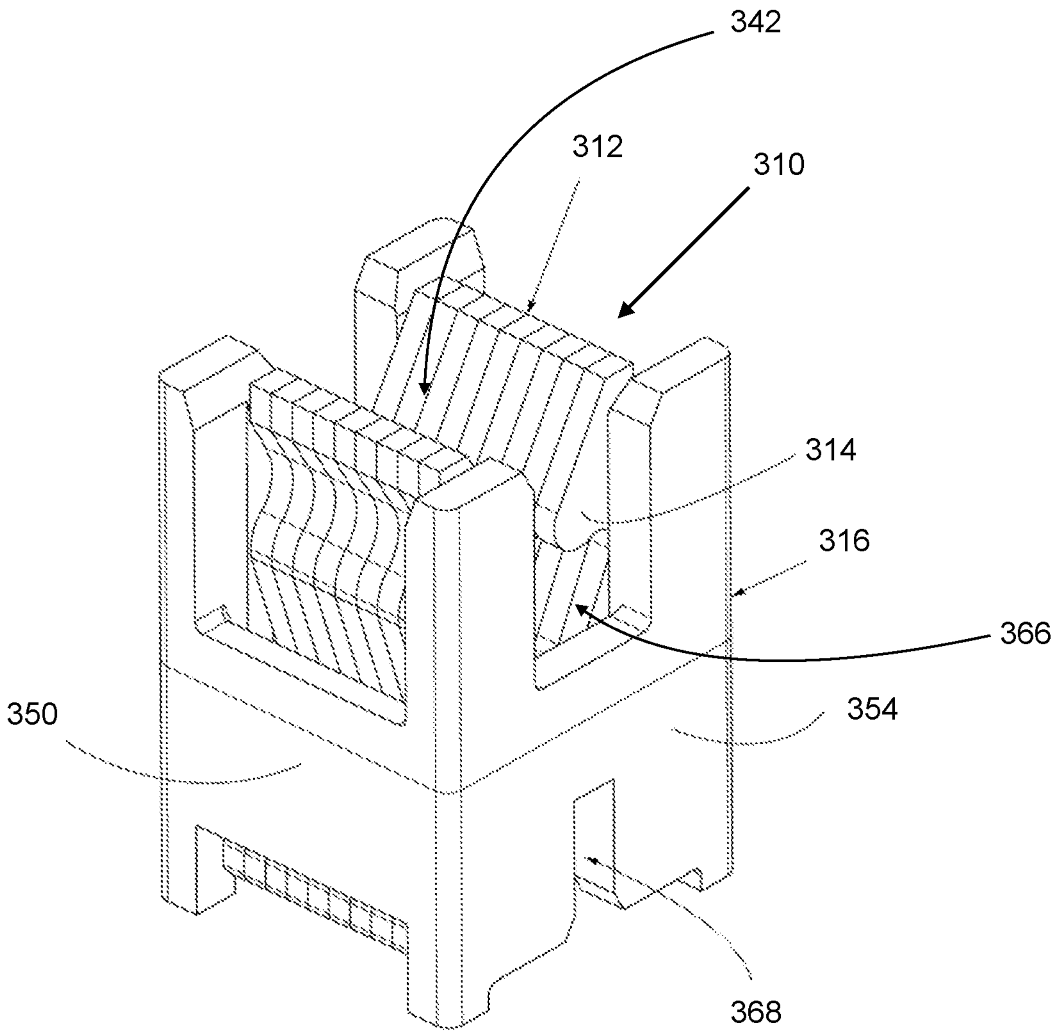

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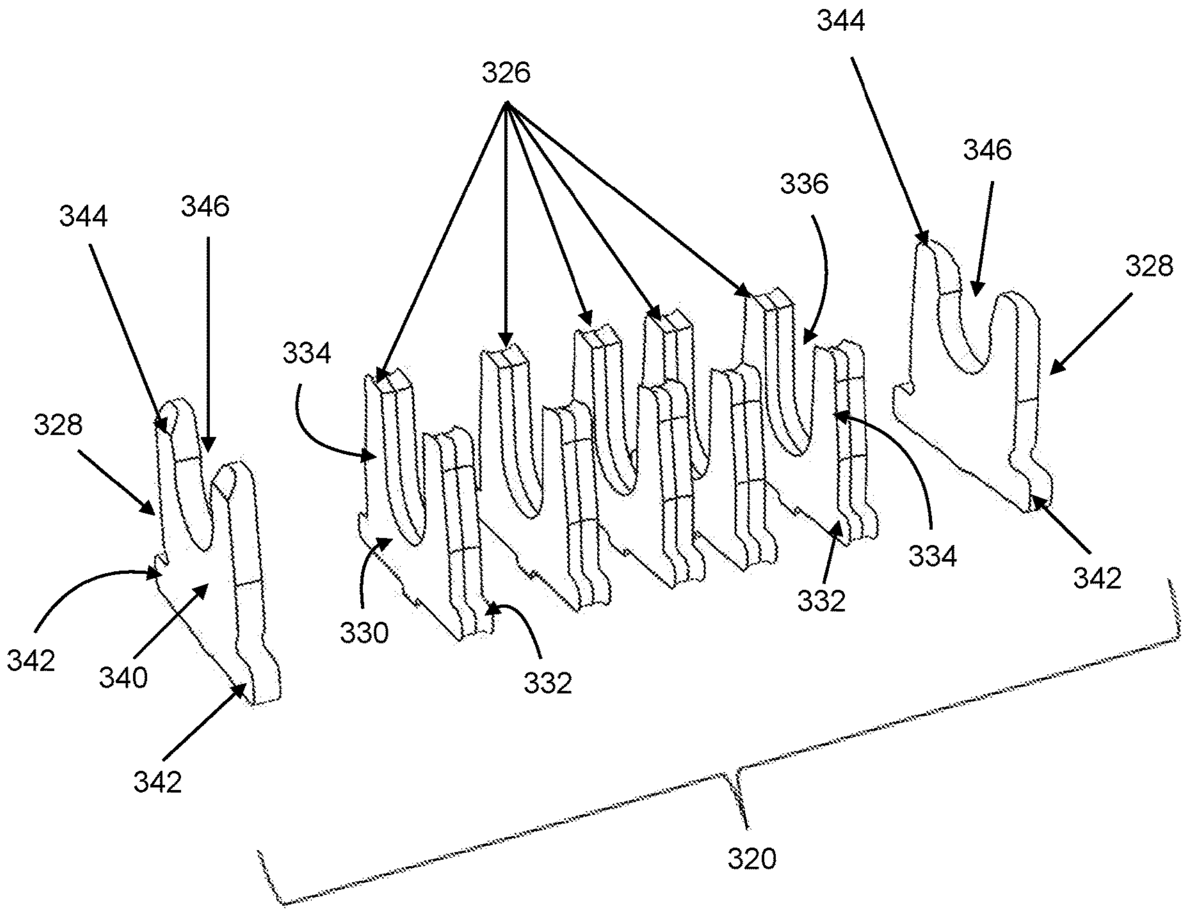
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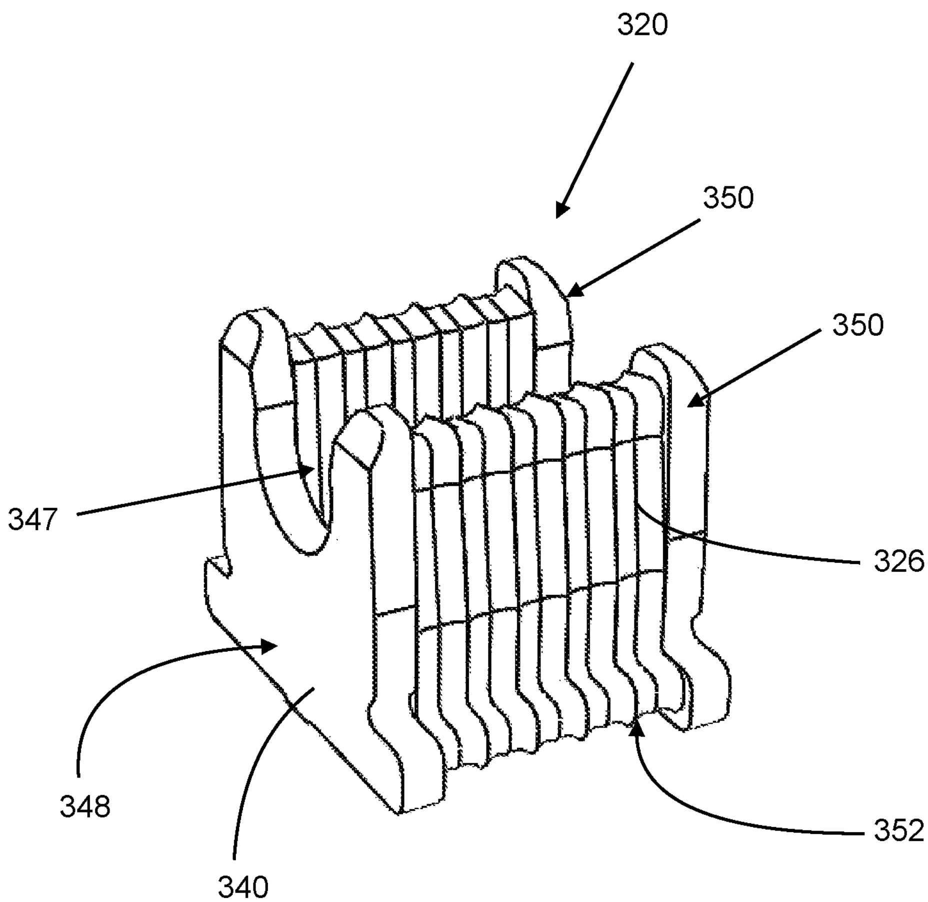
FIG. 25



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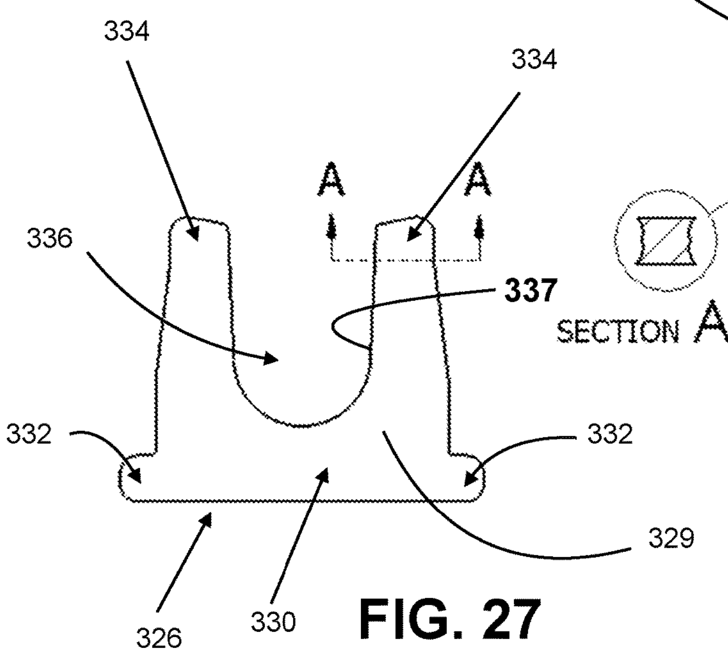
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FIG. 27

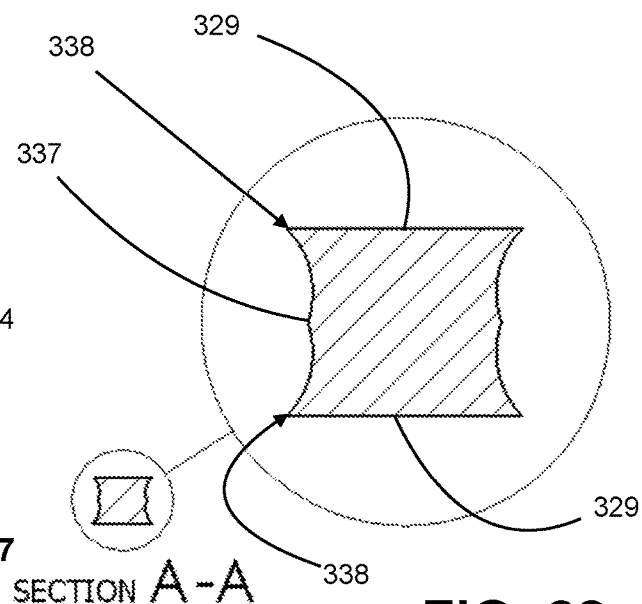
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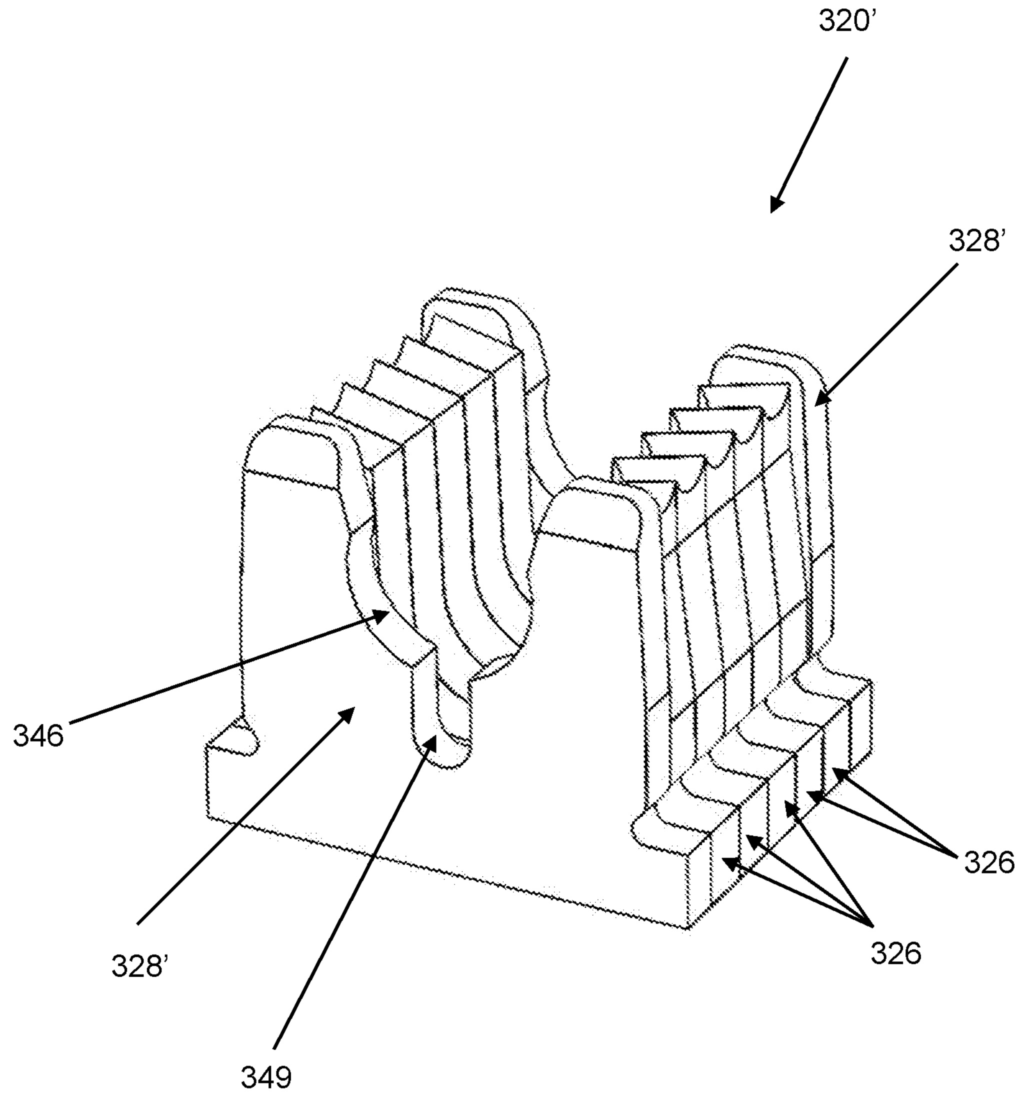
FIG. 28



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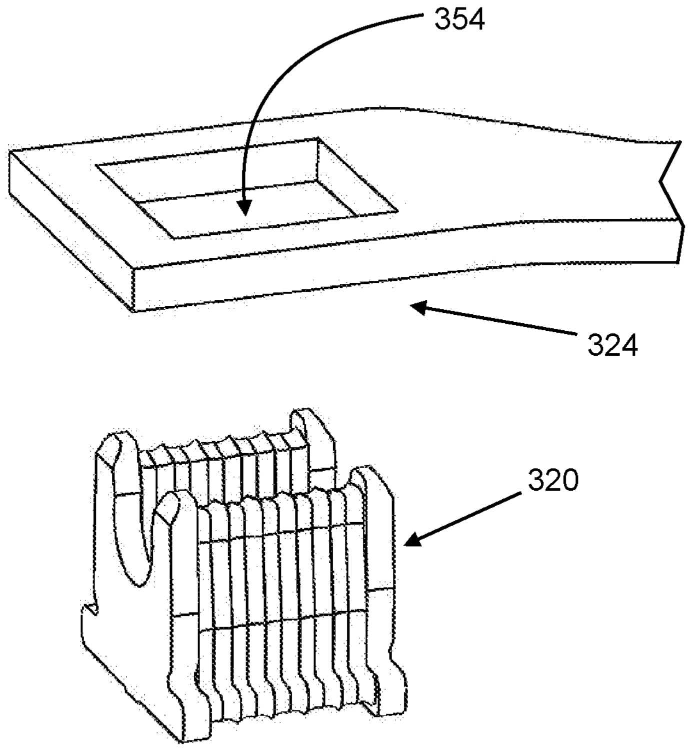

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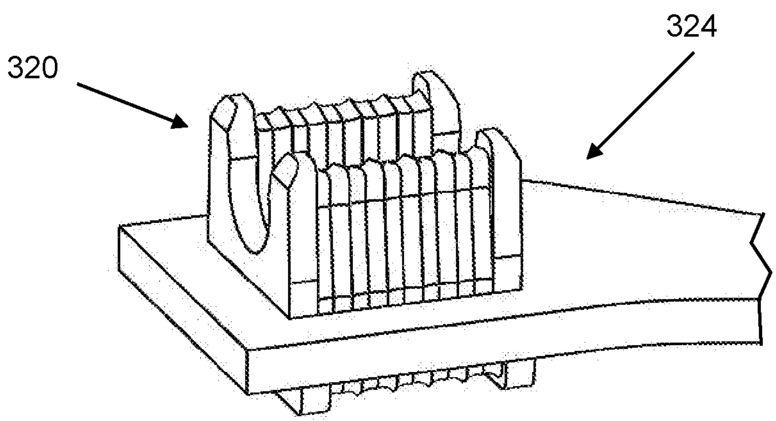

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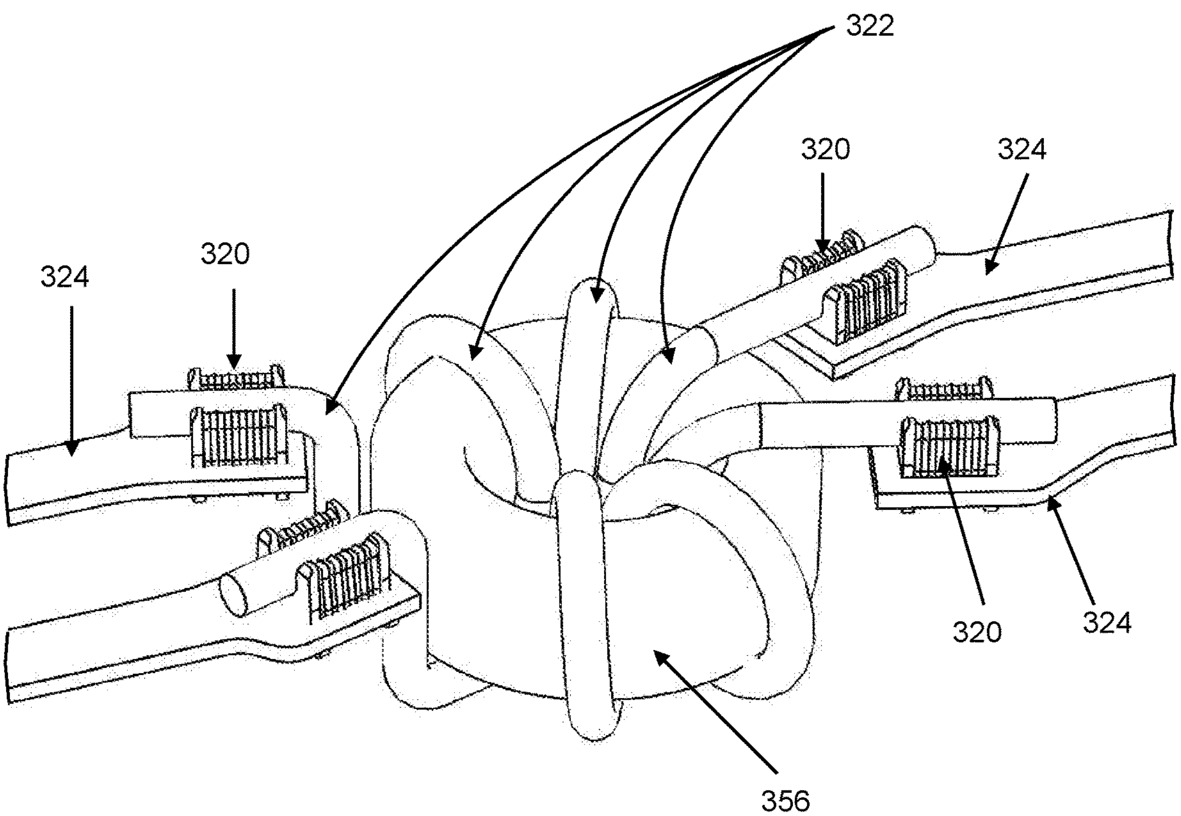

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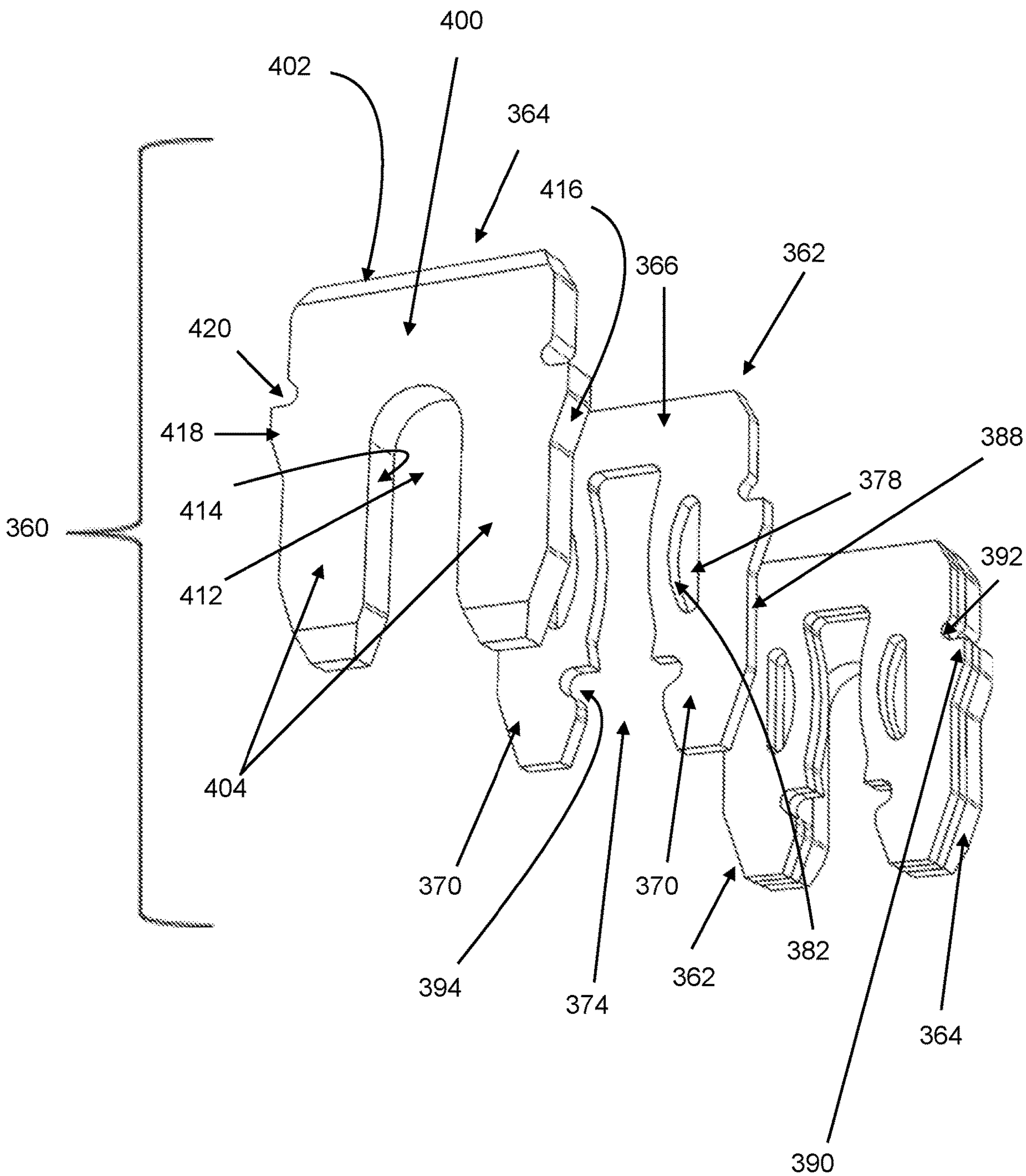
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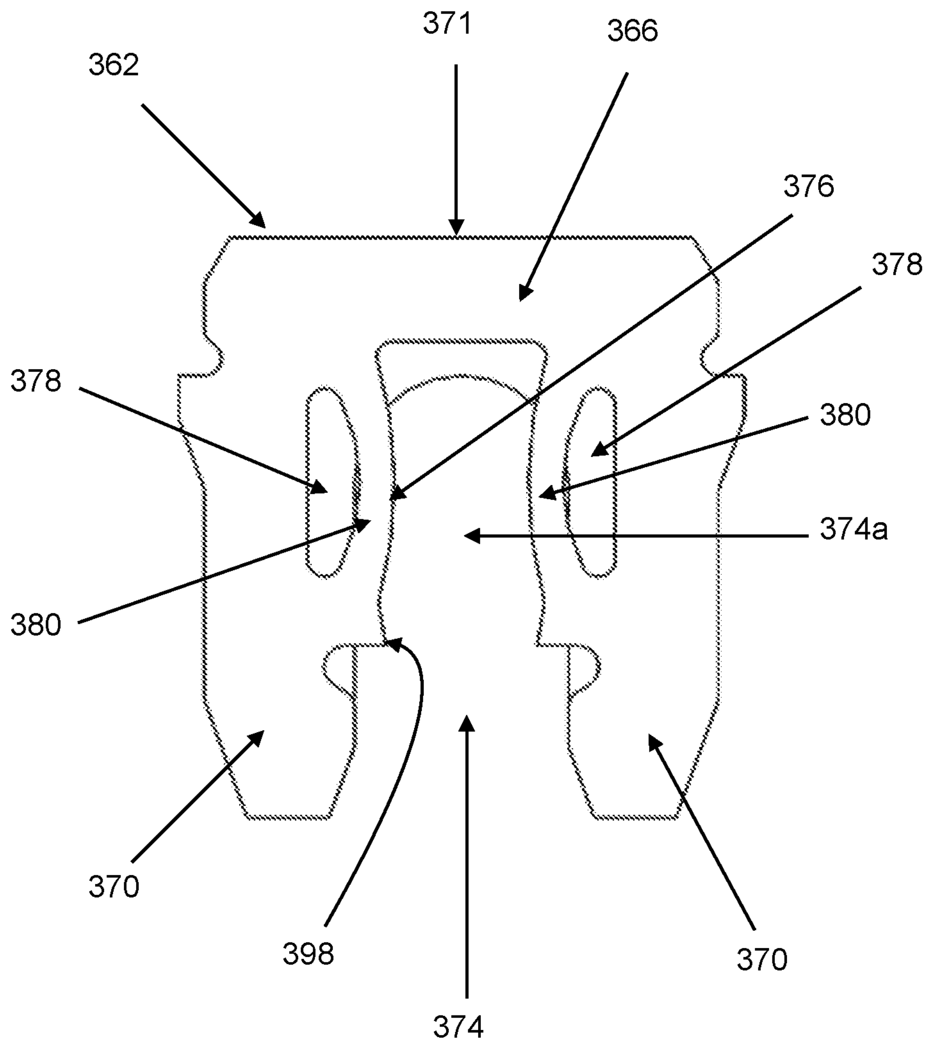
FIG. 33



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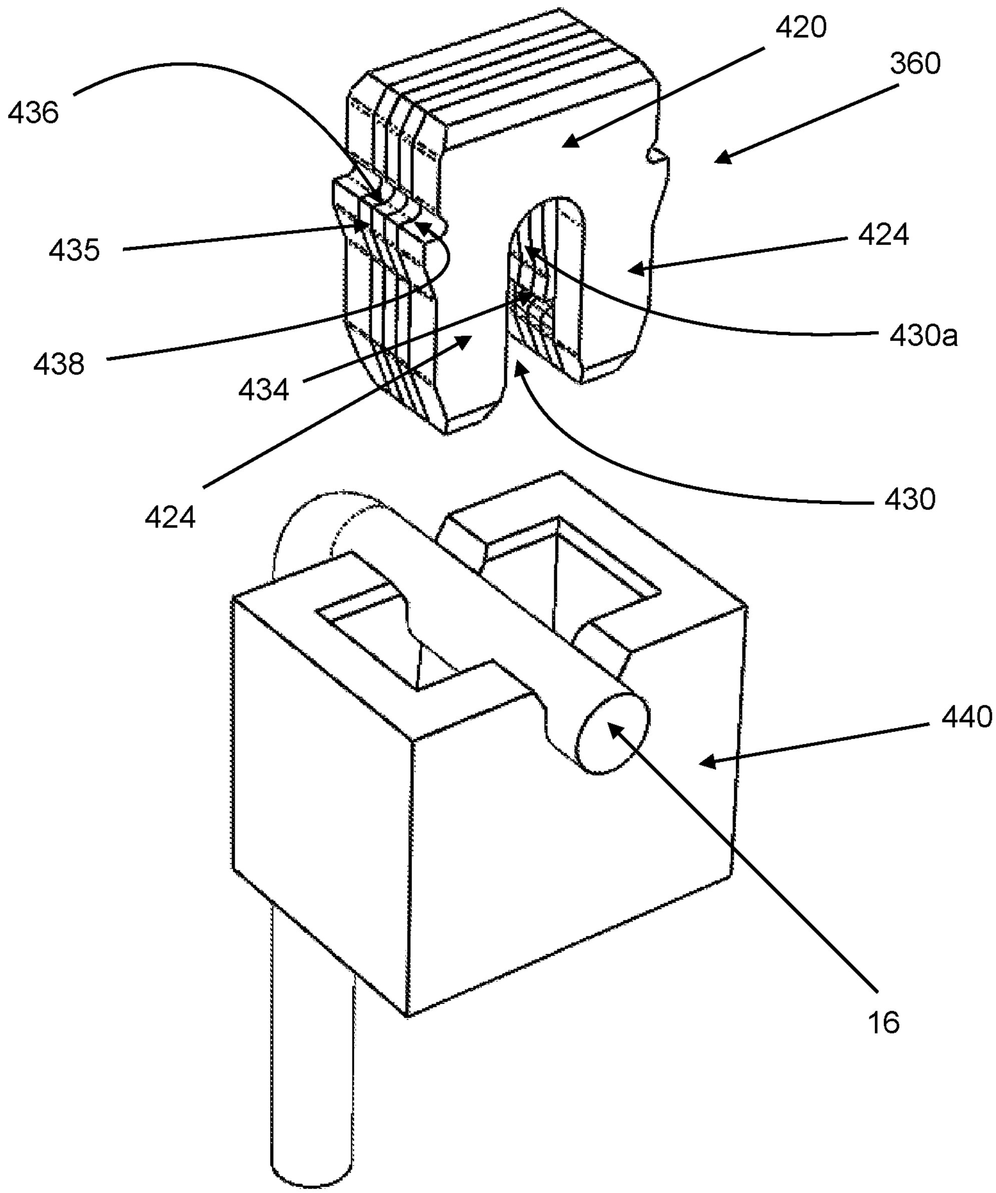
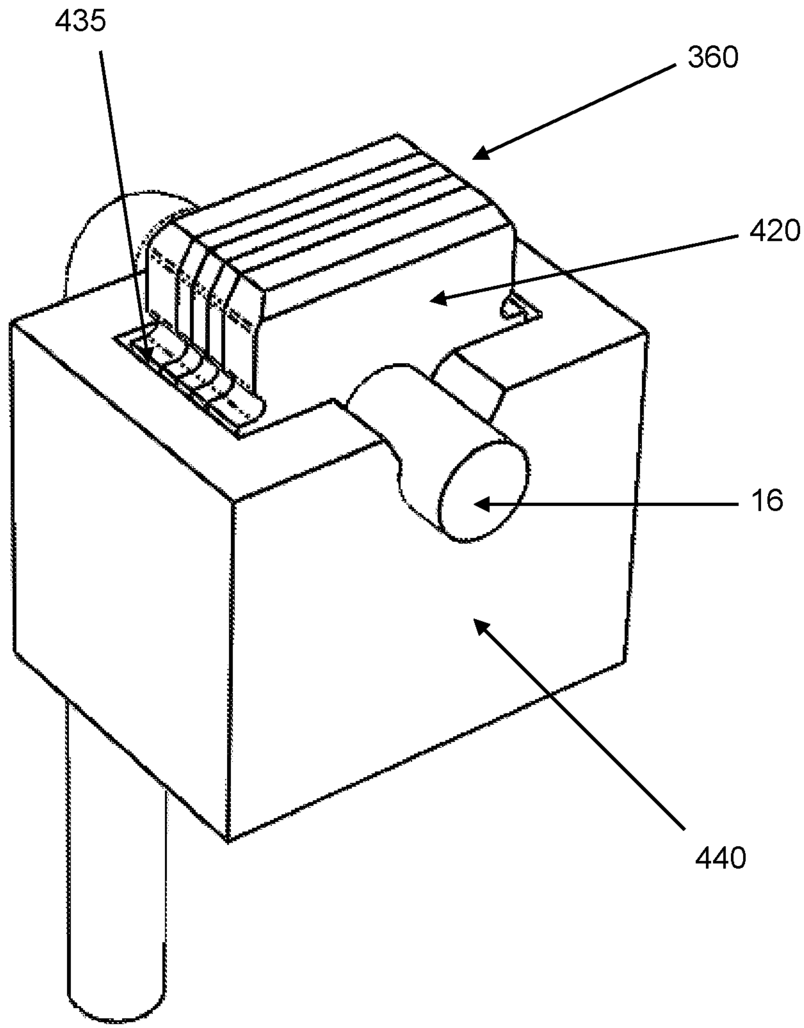


FIG. 35



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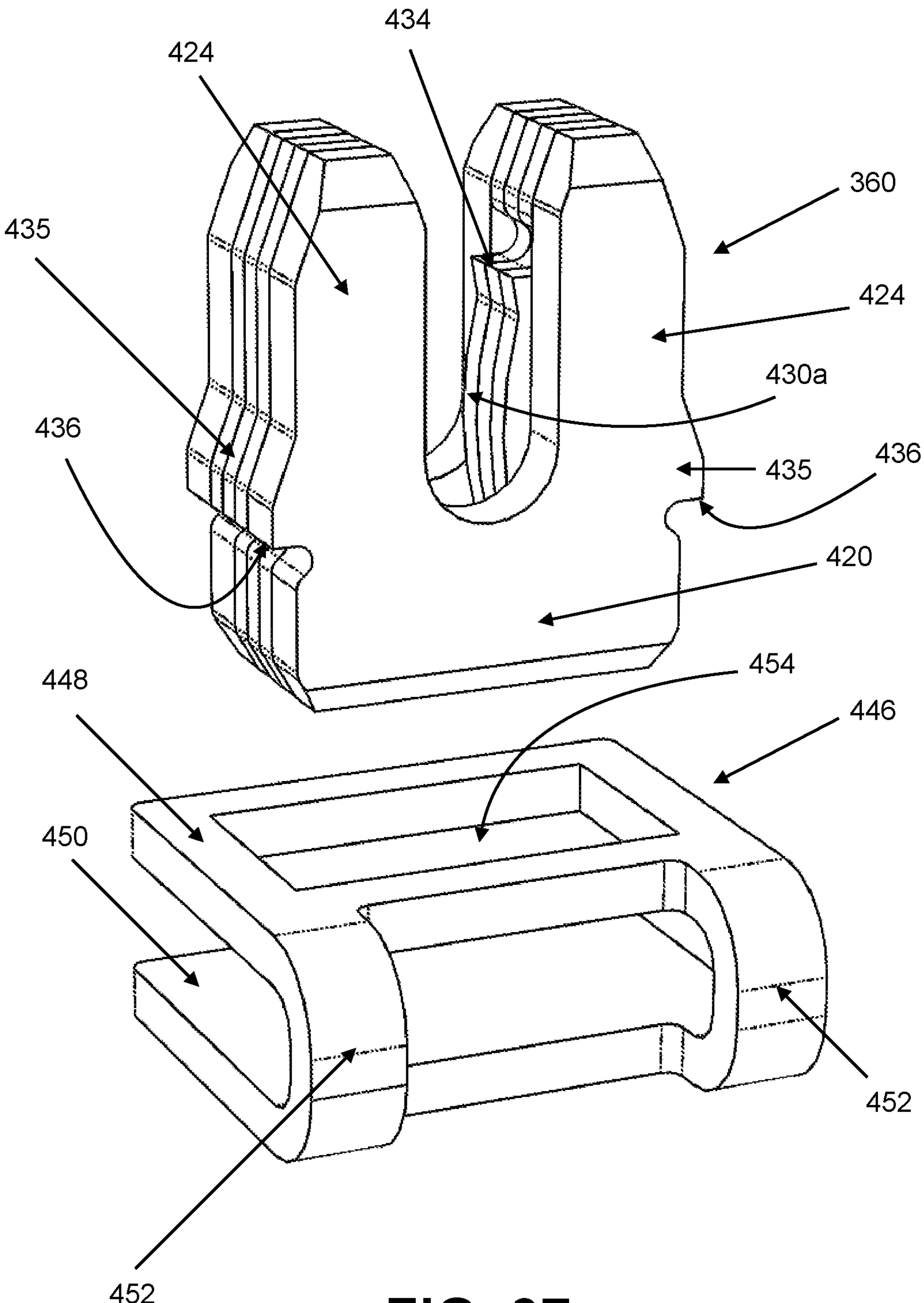

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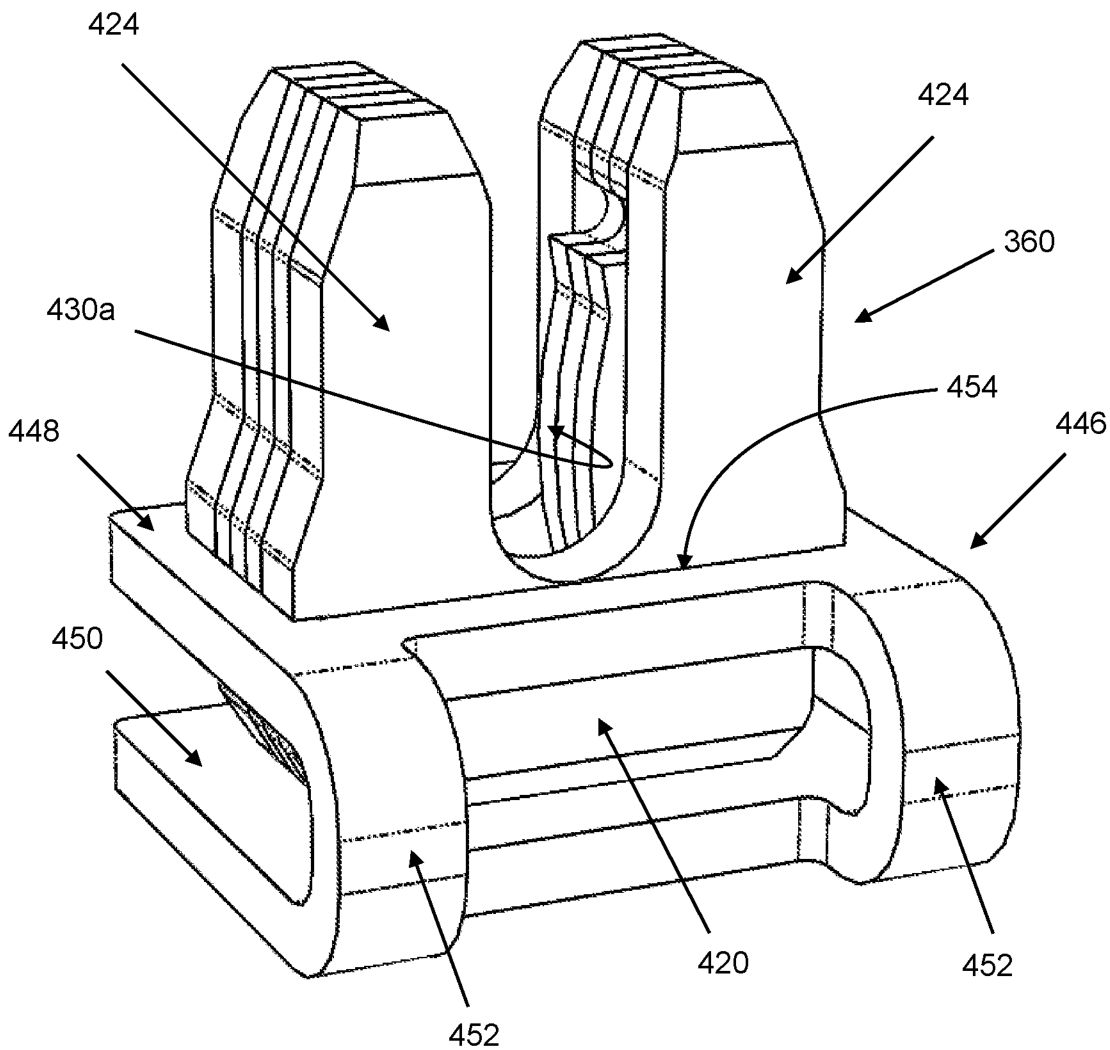

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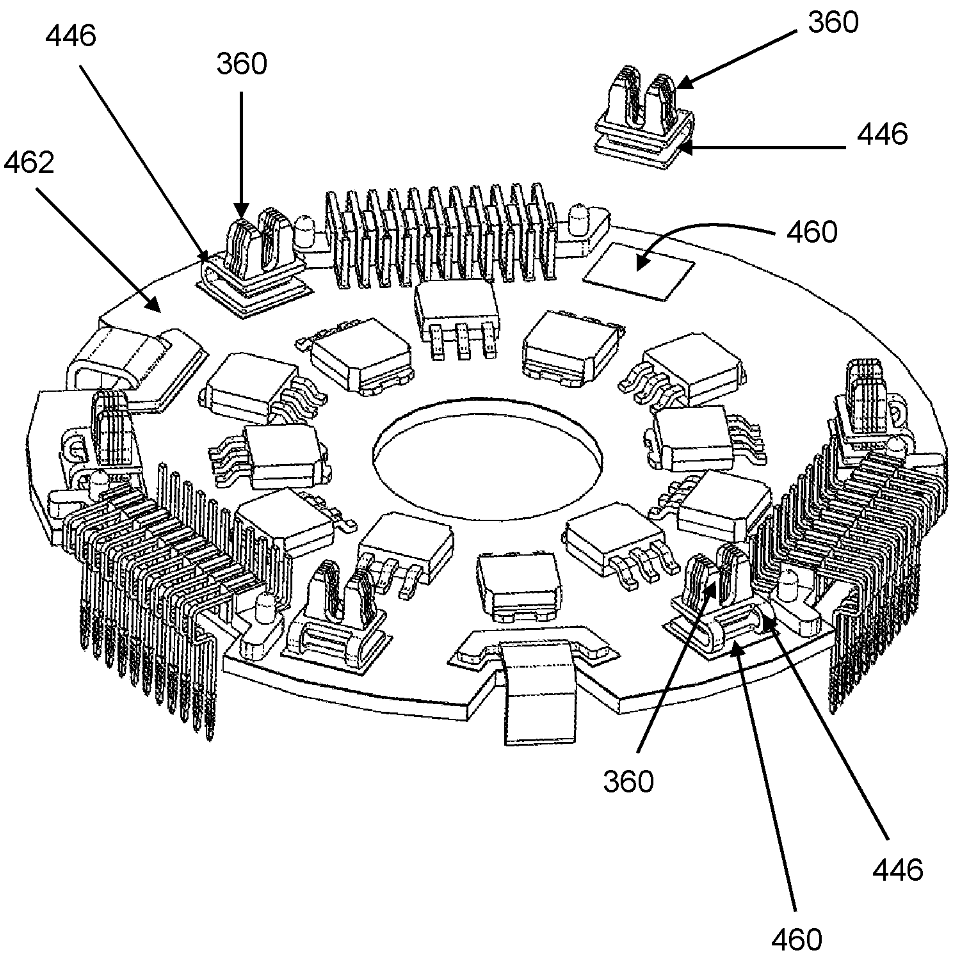

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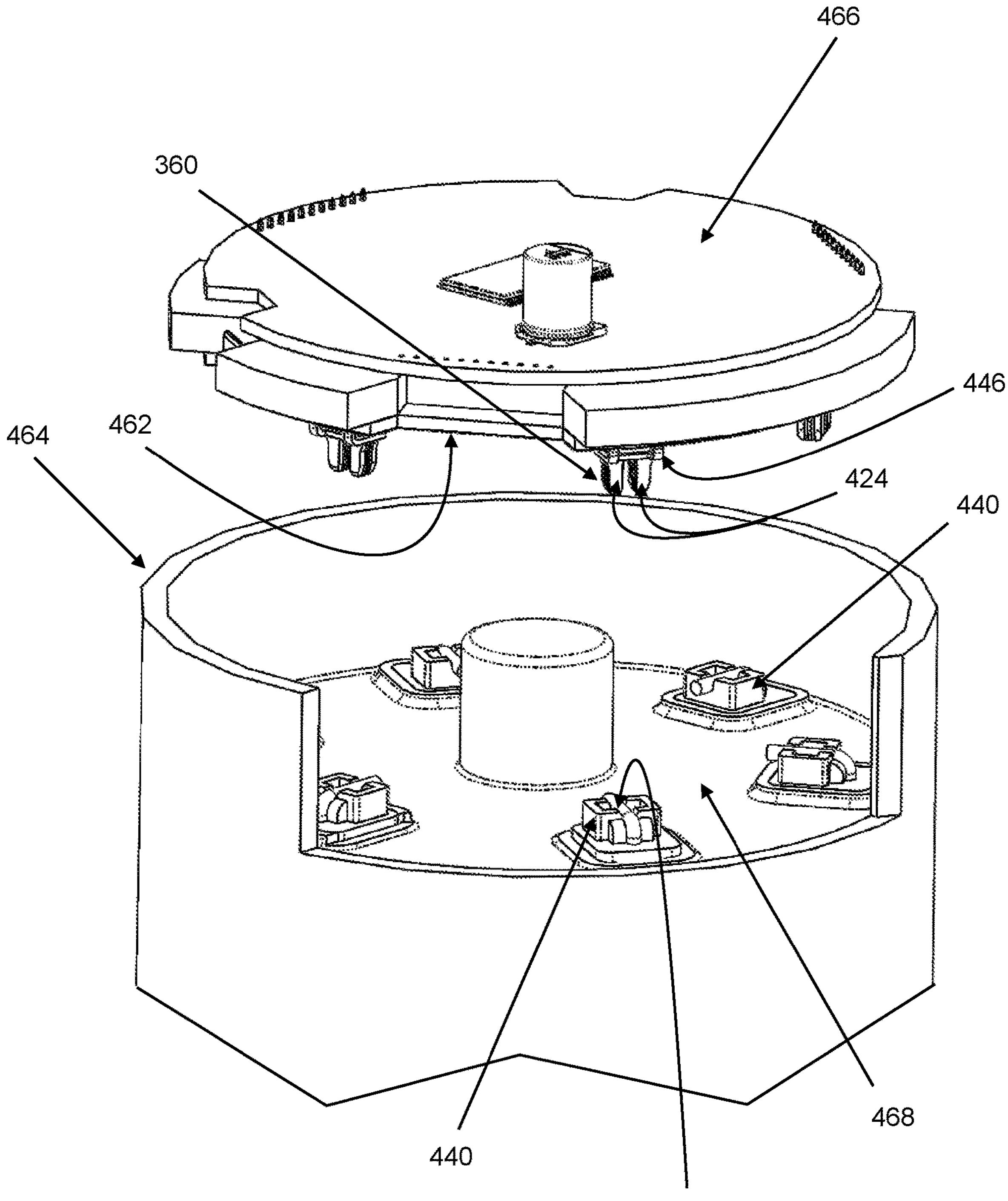

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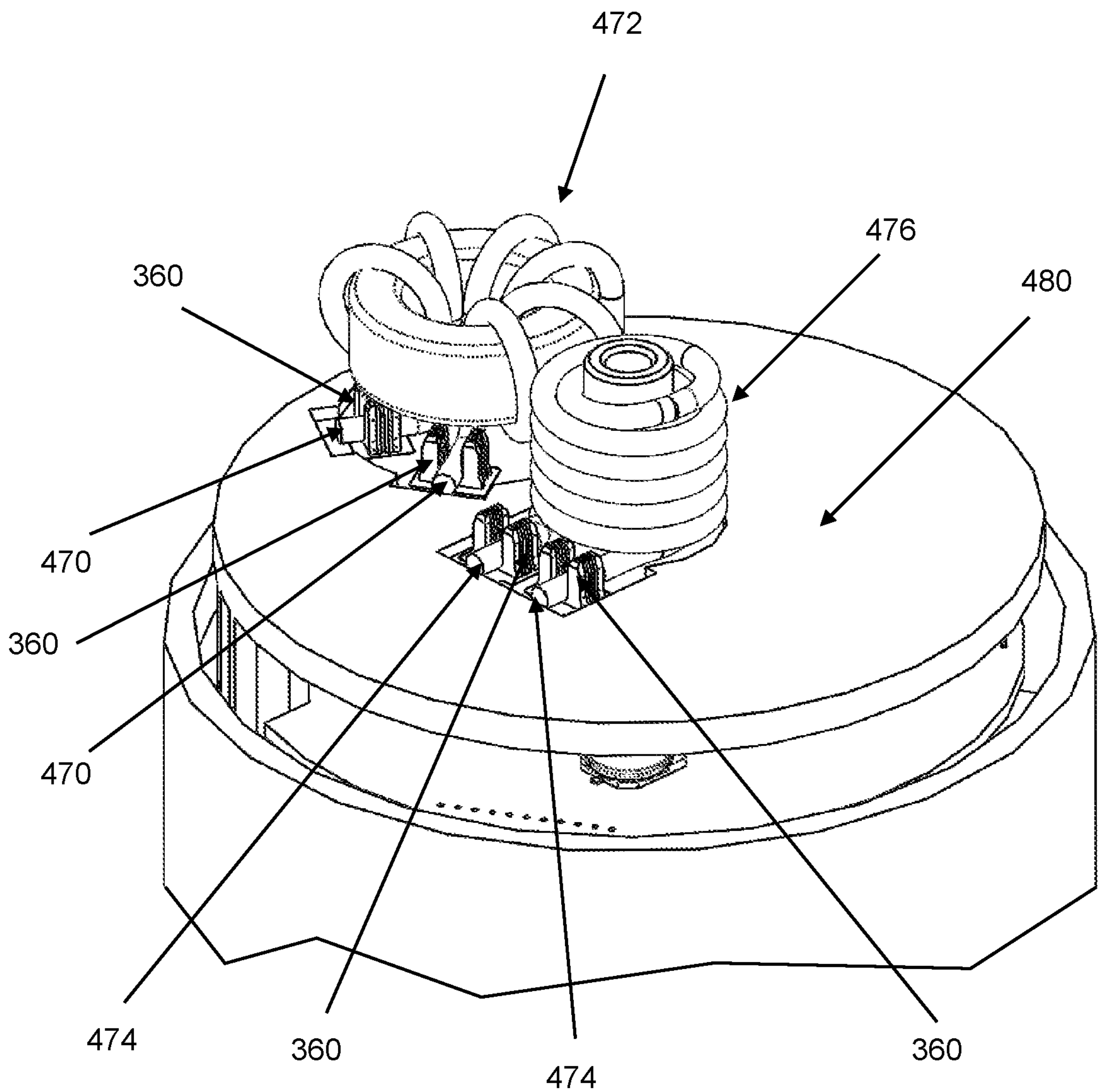

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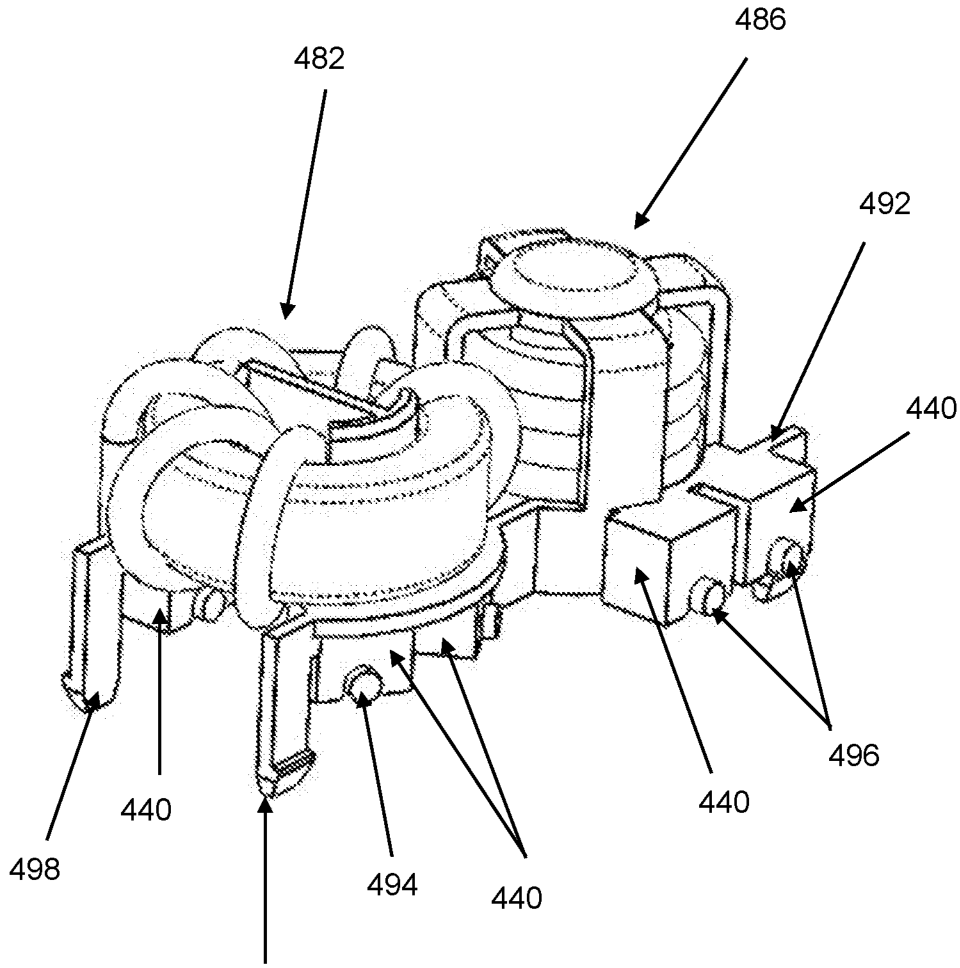

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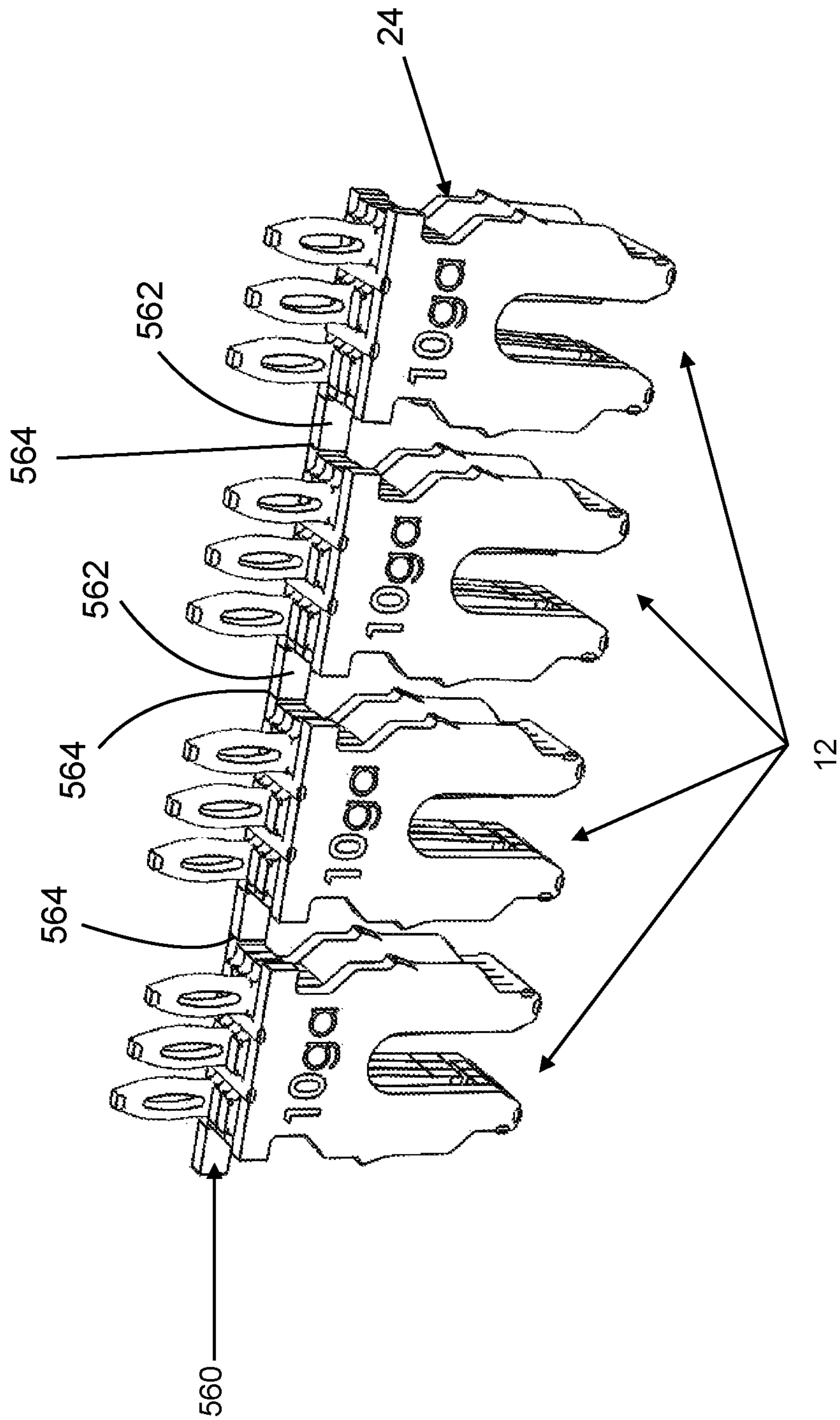

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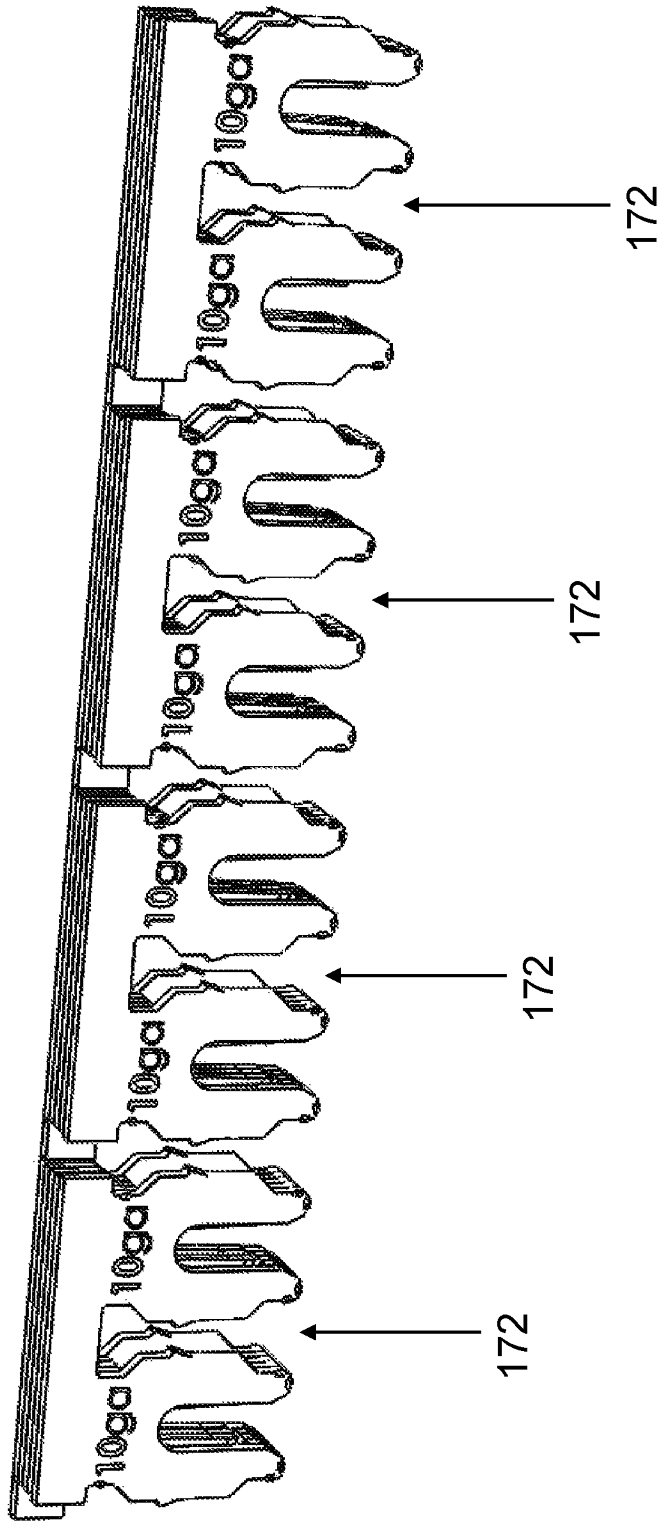

FIG. 44

LAMINATED WIRE CONNECTOR

CROSS-REFERENCE TO RELATED APPLICATION(S)

This application is the U.S. national phase of PCT Application No. PCT/US2019/039141 filed on 26 Jun. 2019, which claims the benefit of priority under 35 U.S.C. § 119(e) to U.S. Provisional Patent Application No. 62/690,408, filed on Jun. 27, 2018, and to U.S. Provisional Patent Application No. 62/803,203, filed on Feb. 8, 2019, all of the foregoing patent applications being herein incorporated by reference.

TECHNICAL FIELD

The present disclosure relates to a connector for use in making an electrical connection to wire, more particularly to an insulation displacement connector (IDC) having an insulation displacement terminal (IDT).

BACKGROUND

An IDC with an IDT is used to quickly make an electrical connection to an insulated wire. The IDC often includes a housing, inside of which the IDT makes the electrical connection to the wire. Conventionally, an IDT has spaced-apart legs for disposal and movement over an insulated wire to displace or remove its outer coating or cover so as to expose and make contact with the metal conductor underneath.

Typically, an IDC and its associated IDT are constructed for use with narrow gauge wire. Electrical connections for larger gauge wire are typically made by welding or bolted crimps. However, welding is not aesthetically pleasing and is often difficult, if not impossible, in applications with space constraints. Crimped lugs are also not suitable for applications with space constraints. Moreover, crimped lugs are typically expensive. Accordingly, there is a need for IDCs for use with larger gauge wire.

SUMMARY

In accordance with the disclosure, an insulation displacement connector is provided for making an electrical connection to at least one wire having an inner metal conductor covered with an outer insulation layer. The insulation displacement connector includes a plurality of metal plates secured together to form a stack that defines a passage for receiving the wire. At least one of the plates has a cutting edge for disrupting the insulation layer of the wire to permit the conductor to directly contact the plate.

The insulation displacement connector may further include a housing having a pair of opposing side walls with slots formed therein and an interior pocket accessible through an exterior opening in the housing. The pocket is adapted to receive at least a portion of the stack of the metal plates and is at least partially defined by opposing interior surfaces. The slots are aligned and cooperate with the pocket to form a route extending through the housing. The route is adapted to receive the wire and is aligned with the passage in the stack when the stack is disposed in the pocket.

BRIEF DESCRIPTION OF THE DRAWINGS

The features, aspects, and advantages of the present invention will become better understood with regard to the following description, appended claims, and accompanying drawings where:

FIG. **1** shows a partially exploded perspective view of an insulation displacement connector (IDC) having an insulation displacement terminal (IDT) constructed in accordance with a first embodiment;

FIG. **2** shows a perspective view of the IDT shown in FIG. **1**;

FIG. **3** shows a partially exploded perspective view of the IDT shown in FIGS. **1** and **2**;

FIG. **4** shows a perspective view of an IDT constructed in accordance with a second embodiment;

FIG. **5** shows a perspective view of a cutter plate having three contact projections;

FIG. **6** shows a perspective view of a bottom portion of a leg of a cutter plate;

FIG. **7** shows a perspective view of a portion of an IDT mounted inside a housing of an IDC, with a part of the housing cut away to show the interior thereof;

FIG. **8** shows a schematic view of an IDC connecting a wire to a printed circuit board through a wall of an enclosure;

FIG. **9** shows a partially exploded perspective view of an IDC having an IDT constructed in accordance with a third embodiment;

FIG. **10** shows a partially exploded perspective view of an IDC having an IDT constructed in accordance with a fourth embodiment;

FIG. **11** shows a perspective view of an IDC having an IDT constructed in accordance with a fifth embodiment, with the IDC being connected to a bar;

FIG. **12** shows a partially exploded perspective view of the IDC of FIG. **11**, with the bar removed from the IDC;

FIG. **13** shows a front view of a cutter plate of the IDT shown in FIGS. **11** and **12**;

FIG. **14** shows a front view of a holding plate of the IDT shown in FIGS. **11** and **12**;

FIG. **15** shows a front perspective of the IDT shown in FIGS. **11** and **12**, with a front holding plate removed;

FIG. **16** shows a perspective view of an IDC having an IDT constructed in accordance with a sixth embodiment, with the IDC being connected to a bar;

FIG. **17** shows a partially exploded perspective view of the IDC of FIG. **16**, with the bar removed from the IDC;

FIG. **18** shows a front view of the IDT of FIGS. **16** and **17**;

FIG. **19** shows a front view of a cutter plate and a contact plate of the IDT of FIGS. **16-18**, with the cutter plate being connected to the contact plate;

FIG. **20** shows a front view of a holding plate of the IDT of FIGS. **16-18**;

FIG. **21** shows a front perspective view of the IDT of FIGS. **16-18**, with a front holding plate removed;

FIG. **22** shows a perspective view of an IDT constructed in accordance with a seventh embodiment;

FIG. **23** shows a partially exploded perspective view of the IDT of FIG. **22**;

FIG. **24** shows a perspective view of a coupler that may be connected to the IDT of FIGS. **22** and **23**;

FIG. **25** shows an exploded view of an IDT constructed in accordance with an eighth embodiment;

FIG. **26** shows a side perspective view of the IDT of FIG. **25**;

FIG. **27** shows a front elevational view of a cutter plate of the IDT of FIG. **25**;

FIG. **28** shows a sectional view of the cutter plate taken along line A-A of FIG. **27**;

FIG. **29** shows a variation of the IDT shown in FIGS. **25** and **26**;

FIG. **30** shows the IDT of FIG. **25** being moved into engagement with a busbar having an opening;

FIG. **31** shows the IDT of FIG. **25** mounted in the opening of the busbar of FIG. **30**;

FIG. **32** shows a plurality of the IDTs of FIG. **27** connecting wires from a magnet to a plurality of busbars of FIG. **31**, respectively;

FIG. **33** shows a partially exploded view of an IDT constructed in accordance with a ninth embodiment;

FIG. **34** shows a front view of the IDT shown in FIG. **33**, with a front holding plate removed;

FIG. **35** shows a perspective view of the IDT of FIG. **33** disposed above a housing holding a wire;

FIG. **36** shows a perspective view of the IDT of FIGS. **33** and **35** mounted to the housing of FIG. **35**;

FIG. **37** shows a perspective view of the IDT of FIGS. **33** and **35** disposed above a mounting bracket;

FIG. **38** shows the IDT mounted to the mounting bracket of FIG. **37** to form an CC;

FIG. **39** shows a perspective view of a plurality of the IDCs of FIG. **38** mounted to an electrical/electronic device;

FIG. **40** shows a partially exploded view of an electric machine having the electrical/electronic device of FIG. **39** mounted to an end cap of the machine;

FIG. **41** shows a perspective view of a portion of a machine having a plurality of the IDCs of FIG. **38** connected to coil wires of electrical devices;

FIG. **42** shows a perspective view of electrical devices mounted to a support housing that includes a plurality of IDTs of FIGS. **33** and **35**;

FIG. **43** shows a plurality of the IDTs of FIGS. **1-3** formed on a strip of metal; and

FIG. **44** shows a plurality of the IDTs of FIG. **12** formed on a strip of metal.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

It should be noted that in the detailed descriptions that follow, identical components have the same reference numerals, regardless of whether they are shown in different embodiments of the present disclosure. It should also be noted that for purposes of clarity and conciseness, the drawings may not necessarily be to scale and certain features of the disclosure may be shown in somewhat schematic form.

Spatially relative terms, such as "top", "bottom", "lower", "above", "upper", and the like, are used herein merely for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as they are illustrated in (a) drawing figure(s) being referred to. It will be understood that the spatially relative terms are not meant to be limiting and are intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the drawings.

Referring now to FIG. **1**, there is shown a partially exploded view of an insulation displacement connector (IDC) **10** that includes a laminated insulation displacement terminal (IDT) **12**. The IDC **10** may further include a housing **14**. The IDC **10** is operable to electrically connect an insulated wire **16** to an electrical/electronic device, such as a printed circuit board (PCB) **18**. The wire **16** may have a conventional construction with an inner metal conductor covered with an outer insulation layer, which may be a coating or sheath composed of an insulating polymeric material. The wire **16** may have a diameter of 10 gauge or greater. While the IDC **10** is especially adapted for use with larger gauge wire, its use is not limited to larger gauge wire and may be used with any gauge wire. Also, while the IDT **12** is typically used with a housing (such as the housing **14**) or a mounting bracket, the IDT **12** may be used alone to connect a wire to another electrical conductor. In such a situation, the IDT **12** alone forms the IDC **10**.

With reference now also to FIGS. **2** and **3**, the IDT **12** include a plurality of plates arranged in a stack **22**. The plates include a plurality of cutter plates **20** disposed between outer holding plates **24**. The plates **20**, **24** may directly contact each other or be separated by a thin dielectric layer. Each cutter plate **20** has a monolithic unitary structure and is composed of electrically conductive metal, such as a copper alloy, which may or may not be plated with tin. The cutter plates **20** may, by way of non-limiting example, be formed by stamping. Each cutter plate **20** includes a base **26** having outwardly-extending first and second shoulders **28***a,b*. An upper edge **27** extends between and across the first and second shoulders **28***a,b*. A plurality of spaced-apart mounts **30** may be joined to the upper edge **27**, between the first and second shoulders. A pair of engagement legs **32** extend from the base **26** in a first direction, while one or more contact projections may extend from the base **26** in a second direction, which is opposite the first direction. Each contact projection is adapted for making electrical connection with an electrical/electronic device. By way of non-limiting example, the contact projection may be a press-fit contact projection **34** (as shown in FIGS. **1-3**, **5**, **9**) for securement within a metal-plated hole of the PCB **18**. More specifically, the contact projection **34** may have an eye-of-the-needle construction with a piercing **38** forming a pair of resiliently deflectable beams **40** for engaging the plated wall of defining a hole of PCB. Alternately, the contact projection may be a pin for soldering in a hole of a PCB, or a weld tab **36**, as shown in FIG. **4**, or may have some other type of construction, as described below.

In those embodiments where each cutter plate **20** has only one contact projection, (such as a pin or contact projection **34**), the location of the contact projection may be the same in each of the cutter plates **20**. For example, in each of the cutter plates **20**, the contact projection may be integrally joined to and extend from a center one of the mounts **30** of the base **26**. In this manner, when the cutter plates **20** are arranged in the stack **22**, the contact projections will be aligned to form a row in the stacking direction of the cutter plates **20**, between the outer plates **24**. Alternately, the contact projection may have a different location in each of the cutter plates **20**. For example, in the embodiment shown in FIGS. **1-3**, the IDT **12** has three cutter plates **20***a*, **20***b*, **20***c*, with the contact projection being in a different location in each one. In the cutter plate **20***a*, the contact projection **34** is integrally joined to and extends from a first outer one of the mounts **30**, located toward the first shoulder **28***a*, whereas in the cutter plate **20***b*, the contact projection **34** is integrally joined to and extends from the center one of the mounts **30**, and in the cutter plate **20***c*, the contact projection **34** is integrally joined to and extends from a second outer one of the mounts **30**, located toward the second shoulder **28***b*. In this manner, when the cutter plates **20** are arranged in the stack **22**, the contact projections form a row that extends diagonally across the IDT **12**, i.e., extends both in the stacking direction, between the holding plates **24**, and in the lateral direction, between the first and second shoulders **28***a,b* of the cutter plates **20**.

Referring now to FIG. **5**, there is shown an embodiment, wherein a cutter plate **20***d* has three contact projections **34** integrally joined to and extending from the mounts **30**, respectively. In this embodiment, the contact projections **34** are aligned to form a row that extends in the lateral direction, between the first and second shoulders **28***a,b* of the cutter plate **20***d*. Although not shown, a cutter plate **20** may be provided having two contact projections (such as a pin or contact projection **34**), which may be integrally joined to the center one of the mounts **30** and a mount **30** adjacent thereto, respectively, or may be integrally joined to the first and second outer ones of the mounts **30**, respectively. In addition, a cutter plate **20** may have no contact projections **34** at all, such as the cutter plate **20***e* shown in FIG. **4**. Still further, a cutter plate **20** may be provided having more than three mounts **30** and more than three contact projections **34**, depending on the application of the IDT **12**.

It should be appreciated that the number of cutter plates **20** used in an IDT **12** may be varied, depending on the requirements for a particular application. The number may be determined by the amount of electrical current the IDT **12** is designed to handle, with the current carrying capacity of the IDT **12** being increased by increasing the number cutter plates **20** that are used. As such, an IDT **12** may have greater or less than the three cutter plates **20** shown in FIGS. **1-3**. In addition, different arrangements of different cutter plates **20** may be utilized, depending on the need. For example, one cutter plate **20***d* (with three contact projections) may be centrally disposed between two cutter plates **20***e* having no contact projections. In another example, one cutter plate **20***d* may be centrally disposed between two stacks of cutter plates **20***b*. In this example, the contact projections of the IDT **12** would form a row extending in the stacking direction and an intersecting row extending in the lateral direction, thereby forming a cross. In still another example, shown in FIG. **4**, an IDT **12***a* has a cutter plate **20***f* with the weld tab **36** centrally disposed between cutter plates **20***e* having no contact projections.

As best shown in FIGS. **3** and **5**, each engagement leg **32** of a cutter plate **20** has an upper portion joined to the base **26** and a lower portion forming a free end **44**. The engagement legs **32** are spaced-apart to form a slot **46** therebetween. The slot **46** has an arcuate, closed end, located toward the base **26**, and an open end, located at the free ends **44**. A holding portion **46***a* of the slot **46** is defined by opposing first inner side surfaces **52** of the engagement legs **32**, respectively. The first inner side surfaces **52** have a slight convex curvature such that the holding portion **46***a* is most narrow at a point about midway along the length of the holding portion **46***a*. The engagement legs **32** have first outer side surfaces **56** located opposite the first inner side surfaces **52**, respectively. The first outer side surfaces **56** are concave. In this manner, the engagement legs **32** are narrowest at the point where the holding portion **46***a* of the slot **46** is narrowest. The foregoing construction of the engagement legs **32** makes them elastic, but with a high degree stiffness, which enables the engagement legs **32** to store enough force to maintain an acceptable contact force on the conductor of the wire **16** disposed in the holding portion **46***a*, even when the cross-section of the conductor of the wire **46** decreases due to mechanical creep. In other words, the engagement legs **32** function as springs to generate a high normal force connection to the conductor of the wire **16**.

With particular reference now to FIG. **6**, notches **58** are formed in the engagement legs **32**, toward the free ends **44**, respectively. The notches **58** are arcuate and are defined by curved inner surfaces **60**, respectively, which adjoin the first inner side surfaces **52** at sharp corner edges **62**, respectively. The sharp edges **62** extend in the direction of the thickness of the cutter plate **20** and function as scrapers and/or cutters for piercing the insulation layer of the wire **16** and are hereinafter referred to as cutters **62**. Below the notches **58**, the engagement legs **32** each have second and third inner side surfaces **64**, **66** and a second outer side surface **68**. The second inner side surfaces **64** are substantially straight and are located outward from the first inner side surfaces **52**, respectively. The third inner side surfaces **66** slope outward from the second inner side surfaces **64** to the free ends **44**, respectively. The second and third inner side surfaces **64**,**66** define an entrance portion **46***b* of the slot **46**. The width of the entrance portion **46***b* is greatest at the free ends **44** and then, as the slot **46** continues toward the base **26**, continuously decreases until it reaches the space between opposing second inner side surfaces **64**, at which point, the width remains constant until the notch **58** is reached.

Referring back to FIGS. **2**, **3** and as described above, the cutter plates **20** are disposed between the holding plates **24**, which have a construction generally similar to the cutter plates **20**. Unlike the cutter plates **20**, however, the holding plates **24** do not have any cutters or scrapers for removing the insulation layer from the wire **16**. In addition, the holding plates **24** are typically thicker than the cutter plates **20**. The holding plates **24** each have a monolithic unitary structure and are composed of electrically conductive metal, such as a copper alloy, which may or may not be plated with tin. The holding plates **24** may, by way of non-limiting example, be formed by stamping. Each holding plate **24** includes a base **72** having a smooth, planar upper edge **74** extending, uninterrupted, between and across first and second shoulders **7***a,b*. A pair of legs **76** extend from the base **72** in a first (downward) direction. In some embodiments (discussed later), one or more contact projections may extend from the upper edge **74** of the base **72** in a second direction, which is opposite the first direction.

Each leg **76** of the holding plates **24** has an upper portion joined to the base **72** and a lower portion forming a free end **80**. The legs **76** are spaced-apart to form a slot **82** therebetween. The slot **82** has an arcuate, closed end, located toward the base **72**, and an open end **82***b*, located at the free ends **80**. The legs **76** each have an angular outer side surface **88** with a main portion **88***a* disposed between a first sloping portion **88***b* and a second sloping portion **88***c*, which slopes inward to a lower portion **88***d*. Barbs **92** protrude from the main portions **88***a*, respectively. As will be described more fully below, the barbs **92** are resiliently deformable to engage interior surfaces of the housing **14**. Upper portions of inner side surfaces **96** of the legs **76** are straight and define a main portion of the slot **82**, which has a uniform width, except at the closed end. The width of the main portion of the slot **82** in each holding plate **24** is the same as the width between the second inner side surfaces **64** of the cutter plates **20**. Lower portions of the inner side surfaces **96** slope outward to define an enlarged entrance portion **82***b* of the slot **82**, which has a width greater than the width of the main portion of the slot **82**.

The holding plates **24** have a more rigid construction than the cutter plates **20**. For example, the outer side surfaces **88** of the legs **76** are not concave and, thus, are not resiliently deflectable. Moreover, as described above, the holding plates **24** are typically thicker than the cutter plates **20**. Accordingly, the the holding plates **24** are more rigid than the cutter plates **20** in a lateral direction, i.e., in a direction normal to the direction of the passage **102** formed by the cutter plates **20** and the holding plates **24** (described below).

The cutter plates **20** and the holding plates **24** are arranged in the stack **22** so as to provide the IDT **12** with a base **98** (which is formed by the bases **26**, **72** of the cutter plates **20** and the holding plates **24**) and a pair of legs **100** (which are formed by the engagement legs **32** of the cutter plates **20** and the legs **76** of the holding plates **24**). Each leg **100** has an outer boundary delimited by the outer side surfaces **88** of the holding plates **24** and an inner boundary delimited by the first and second inner side surfaces **52**, **64** of the engagement legs **32** of the cutter plates **20**.

The legs **100** of the IDT **12** are separated by a passage **102** that is formed by the slots **46** in the cutter plates **20** and the slots **82** in the holding plates **24**. The holding portions **46*a*** of the cutter plates **20** are aligned with each other to form a holding portion **102*a*** of the passage **102**, which is disposed inward from the upper portions of the inner side surfaces **96** of each of the holding plates **24**. The second inner side surfaces **64** of the cutter plates **20**, however, are aligned with the upper portions of the first inner side surfaces **96** of the holding plates **24**, and the third inner side surfaces **66** of the cutter plates **20** are aligned with the lower portions of the inner side surfaces **96** of the holding plates **24**. In this manner, the slots **82** in the holding plates **24** are aligned with the entrance portions of the slots **46** in the cutter plates **20** and provide the passage **102** of the IDT **12** with an entrance portion **102*b***. At the juncture between the entrance portion **102*b*** and the holding portion **102*a*** of the passage **102**, the cutters **62** in each of the legs **100** are aligned to form a laminated cutting edge **108**.

In the base **98** of the IDT **12**, the upper edges **27** of the cutter plates **20** are aligned with each other and with the upper edges **74** of the holding plates **24** to provide the base of the IDT **12** with an upper surface **103**. In each leg **100** of the IDT **12**, the second outer side surfaces **68** of the cutter plates **20** are aligned with each other and with the lower portions **88*d*** of the outer side surfaces **88** of the holding plates **24** to provide the leg **100** with a lower outer side surface **104**. In addition, in each leg **100** of the IDT **12**, the free ends **44** of the of the cutter plates **20** are aligned with each other and with the free ends **80** of the holding plates **24** to provide the leg **100** with a free end **106**.

The plates **20**, **24** may be secured together by mechanical means and/or by welding. The plates **20**, **24** may be mechanically held together by a bracket or a band in a press-fit manner. For example, a metal band may tightly extend around the IDT **12**, just below the base **98**. The plates **20**, **24** are shown in FIG. **2** being secured together in the stack **22** by electron beam welding or laser beam welding. Welds may be made in a plurality of locations. There may be at least one weld at the top of the base of the IDT **12** and at least one weld in each leg **100** of the IDT **12**. As shown, a pair of upper welds **110** may be made across the upper surface **103** of the base **98** of the IDT **12**, with each upper weld **110** extending between aligned rows of the mounts **30**. Also as shown, a pair of lower welds **112** may be formed in each leg **100** of the IDT **12**, with one lower weld **112** extending across the lower outer side surface **104** of the leg **100** and the other lower weld **112** extending across the free end **106** of the leg **100**. In forming the welds **110**,**112**, filler metal in the form of wire or powder may be added to control the shape and size of the weld. For example, each weld **110**, **112** may be provided with a crown (convex surface of the weld).

Referring back to FIG. **1** and now also to FIG. **7**, the housing **14** is configured for use with the IDT **12**. The housing **14** may be formed of plastic and may have a cuboidal shape. The housing **14** may be secured to a second electrical/electronic device, such as a PCB, and, as such, may include features for mounting the housing **14** to the second electrical/electronic device. The housing **14** has an interior pocket **114** with a shape that corresponds to the shape of the IDT **12**. The pocket **114** is accessible through an exterior opening **115** in the housing **14**. The pocket **114** is formed by a plurality of interior surfaces, including a pair of opposing dogleg-shaped interior side surfaces **116** that correspond to the outer boundaries of the legs **100** and a pair of interior center surfaces **118** that correspond to the inner boundaries of the legs **100**, respectively. The interior center surfaces **118** are connected by an abutment surface **120** that extends between and through opposing walls **122** of the housing **14**. The abutment surface **120** forms the closed ends of slots **126** that are formed in the walls **122** of the housing **14**, respectively, and extend into the pocket **114**. The slots **126** cooperate with the pocket **114** to form a route through the housing **14**.

The wire **16** extends through the route in the housing **14** and rests against the abutment surface **120**, thereby extending across and through the pocket **114**, as shown. With the wire **16** so positioned, the IDT **12** is disposed over the opening **115**, with the legs **100** disposed toward and aligned with the opening **115** and the passage **102** aligned over the wire **16**. The IDT **12** is then pressed down into the pocket **114**. As the IDT **12** moves into the pocket **114**, the wire **16** (relatively speaking) enters and moves through the entrance portion **102*b*** of the passage **102** unobstructed and then moves into contact with the laminated cutting edges **108**, which pierce and/or cut the insulation layer of the wire **16**. The continued (relative) movement of the wire **16** through the holding portion **102*a*** of the passage **102** displaces and/or removes portions of the insulation layer from the conductor, which then comes into contact with the first inner side surfaces **52** of the cutter plates **20**. Pieces of the insulation layer that are removed from the conductor may be accommodated within the notches **58** of the cutter plates **20** and/or at the bottom of the pocket **114**. The conductor of the wire **16** is held in the holding portion **102*a*** of the passage **102** and engages the first inner side surfaces **52** of the cutter plates **20**, thereby making an electrical connection between the wire **16** and the IDT **12**.

As the IDT **12** moves into the pocket **114**, the barbs **92** contact the interior side surfaces **116** of the housing **14** and are resiliently deflected. The IDT **12** continues to move downward until the second sloping portions **88*c*** of the outer side surfaces **88** of the holding plates **24** contact the interior side surfaces **116** of the housing **14**. At this point, further downward movement of the IDT **12** is prevented. The wire **16** is disposed in the holding portion of the passage **102** and is trapped between and abuts the closed end of the passage **102** and the abutment surface **120** of the housing **14**. The barbs **92** exert forces against the interior side surfaces **116** to retain the IDT **12** in the pocket **114**. Moreover, the conductor of the wire **16** is electrically connected to the IDT **12**.

When the IDT **12** is fully disposed in the pocket **114**, the base **98** of the IDT **12** is disposed above the housing **14** so as to be exposed, i.e., the housing **14** is separated from the contact projections (e.g., **34**). This separation permits the IDC **10** to be connected through a wall **146** of an enclosure **148**, such as is shown in FIG. **8**. The distance by which the contact projections **34** are separated from the housing **14** accommodates the thickness of the wall **146** through which the IDT **12** may extend to provide a connection between the wire **16**, disposed on one side of the wall **146**, and an electrical/electronic device, such as the PCB **18**, disposed on the other side of the wall **146**. The wall **146** may be sealed around the opening through which the IDT **12** extends to seal the wire **16** from the PCB **18**.

The operation of the IDT **12** described above is facilitated by structural features of the IDT **12**. The securement of the cutter plates **20** between the holding plates **24** provide the IDT **12** with structural rigidity. This rigidity ensures that the bite of the cutter plates **20** through the insulation layer and the conductor of the wire **16** is properly sized by preventing the engagement legs **32** of the cutter plates **20** from splaying outward during the cutting action. The structural rigidity of the IDT **12** also allows the engagement legs **32** of the cutter plates **20** to function as springs to generate a high normal force connection to the wire **16**.

It should be appreciated that other laminated IDTs may be provided for applications other than connecting a wire to a PCB. Non-limiting examples of some of these laminated IDTs are described below. A first one of these examples is the IDT **150** shown in FIG. **9** to which reference is now made. The IDT **150** is adapted for connecting a wire, such as wire **16**, to a metal busbar **160** for distributing power. The busbar **160** is composed of a conductive metal, such as a copper alloy, and has a series of holes **162** and a pair of slots **164** extending therethrough.

The IDT **150** has the same construction as the IDT **12**, except the IDT **150** has holding plates **154** instead of the holding plates **24**. The holding plates **154** have the same construction as the holding plates **24**, except the holding plates **154** each have a tongue **156** joined to the upper edge **74** and extending upwardly therefrom. The tongues **156** each have a tapered free end. The tongues **156** are located proximate to the shoulders **78** one opposing sides of the IDT **15**, respectively, i.e., are arranged diagonal to each other. In this manner, the tongues **156** and the contact projections **34** form an outline of a parallelogram, as viewed from the top of the IDT **150**.

The arrangement of the tongues **156** and the contact projections **34** of the IDT **150** corresponds to the arrangement of the holes **162** and the slots **164**, respectively, of the busbar **160**. Moreover, the contact projections **34** are sized to resiliently deform when they are pressed into the holes **162**, respectively, and the tongues **156** are sized to be snugly received in the slots **164**, respectively. The outward forces applied by the beams **40** of the contact projections **34** against the inner walls of the busbar **160** defining the holes **162** helps retain the contact projections **34** in the holes **162**. The disposal of the tongues **156** in the slots **164** provides strain relief that helps prevent cold-working of the holes **162** by the contact projections **34**.

Referring now to FIG. **10**, there is shown an IDC **170** for connecting together (e.g. splicing) two wires **16***a,b*. The IDC **170** includes a laminated IDT **172** and a housing **174**.

Except as described below, the IDT **172** has the same construction as two IDTs **12** arranged side-by-side and integrally joined together at their shoulders. A base **176** of the IDT **172**, including its shoulders, is higher than the base **98** of the IDT **12** and its shoulders. In addition, the base **176** of the IDT **172** is wider than the combined length of the bases **98** of two IDTs **12** due to the additional length in the center necessary to separate the two pairs of inner legs **100** of the IDT **172**. Although the IDT **172** is shown as not having any contact projections extending from its upper surface, it should be appreciated that in other embodiments, the IDT **172** may have contact projections (such as pins or contact projections **34**).

The housing **174** has the same construction as two housings **14** arranged side-by-side and integrally joined together. The spacing between the pockets **114***a,b* of the housing **174** corresponds to the spacing between the two pairs of legs **100***a,b*. In this manner, a first pair of the legs **100***a* may be inserted into the pocket **114***a* at the same time a second pair of the legs **100***b* is inserted into the pocket **114***b*. When the wires **16***a,b* extend through the routes in the housing **174**, as shown, and the pairs of legs **100** are inserted into the pockets **114***a,b*, the laminated cutting edges **108** of the legs **100** remove the insulation layers from the conductors of the wires **16***a,b*, which then come into contact with the legs **100**, thereby electrically connecting each of the wires **16***a,b* to the IDT **172** and in so doing, electrically connecting together the wires **16***a,b*.

Referring now to FIGS. **11-15**, there is shown an IDC **180** for connecting a wire **16** to a bar **182** (such as a power busbar) that does not have holes formed therein. The IDC **180** includes an IDT **184** and a housing **14**.

The IDT **184** includes a plurality of plates arranged in a stack **186**. The plates include a plurality of cutter plates **20***g* disposed between outer holding plates **190**. The plates **20***g*,**190** may directly contact each other or be separated by a thin dielectric layer. Each cutter plate **20***g* has a contact projection **192** joined to and extending upward from the upper edge **27** of the base **26**. The contact projection **192** has a configuration similar to a tuning fork and comprises a pair of arms or tines **194**, each of which are gently tapered and have an outer end portion **194***a* joined at a bend **194***b* to a main portion **194***c*. The tine main portions **194***c* slope inwardly, toward each other, while the tine outer end portions **194***a* extend outwardly, respectively. As such, the tines **194** define a spacing **196** having a V-shaped outer portion **196***a* located between the tine outer end portions **194***a*, a narrow neck portion **196***b* located between the tine bends **194***b* and a teardrop-shaped inner portion **196***c* defined by the tine main portions **194***c*.

The holding plates **190** (shown best in FIG. **14**) have the same construction as the holding plates **24**, except the holding plates **190** each have a body **200** integrally and seamlessly joined to the upper edge **74** and extending upwardly therefrom. The bodies **200** each have a slot **202** formed therein, which extends through an upper free end **200***a* of the body **200**. Each slot **202** has an outer portion **202***a* that is V-shaped and a main portion **202***b* having a constant width, except at a bottom closed end of the slot **202**. The slot outer portion **202***a* corresponds to the V-shaped outer portion **196***a* of the spacing **196** in the contact projections **192**. The width of the slot main portion **202***b* is slightly wider than the spacing neck portion **196***b* in the contact projections **192**.

The cutter plates **20***g* and the holding plates **190** are arranged in the stack **186** in a manner similar to the plates **20**, **24** in the stack **22** of the IDT **12** so as to provide the IDT **184** with a pair of legs **100** separated by a passage **102**. In addition, the contact projections **192** of the cutter plates **20***g* cooperate to define a laminated contact projection **206** having a slot **208** adapted to receive the bar **182**. The slot **208** includes a V-shaped outer portion **208***a* and a main portion **208***b*. The V-shaped outer portion **208***a* is formed by the outer portions **196***a* of the cutter plates **20***g*. The slot **208** extends in the stacking direction of the cutter plates **20***g* and is aligned with the slots **202** in the holding plates **190**.

It is noted that with regard to the IDT **184**, the X-direction of the IDT **184** is the stacking direction of the cutter plates **20***g*, the Y-direction of the IDT **184** is the lateral direction (from leg **100** to leg **100**) and the Z-direction is the vertical direction, i.e., the direction in which the legs **100** extend.

The plates **20***g*, **190** are secured together in the stack **186** by mechanical means and/or by welding. The plates **20***g*, **190** may be mechanically held together by a bracket or a band in a press-fit manner. For example, a metal band may tightly extend around the IDT **184**, just below the the shoulders **28**, **78** of the cutter plates **20***g* and the holding plates **190**. The plates **20***g*, **190** may be welded together in the same manner as the plates **20**, **24** in the stack **22**, except for the absence of the upper welds **110**. Instead of having upper welds **110**, the stack **186** has upper welds **210** that extend across the tops of the shoulders **28**, **78** of the cutter plates **20***g* and holding plates **190**, respectively. In this manner, the upper welds **210** are disposed at the bottom of, and on opposing sides of, the laminated contact projection **206**. This location permits individual movement of the tines **194** of the cutter plates **20***g* when they are deflected outward by the insertion of the bar **182** in the slot **208** and/or when they resiliently return to their original position if the bar **182** is subsequently removed from the slot **208**.

The electrical connection of the IDT **184** to the wire **16** in the housing **14** is the same as the IDT **12** described above. The IDT **184** may be electrically connected to the bar **182** by moving a blade portion **182***a* of the bar **182** vertically downward (in the Z-direction) into the slot **208** through the outer portion **208***a*. As the blade portion **182***a* moves downward, the blade portion **182** contacts the tine bends **194***b* of the cutter plates **20***g*, thereby deflecting them outward. The tine bends **194***b* maintain contact with the blade portion **182** after the blade portion **182***a* is fully disposed in the slot **208**, thereby establishing an electrical connection between the bar **182** and the IDT **184** and, thus, the wire **16**.

It should be appreciated that the IDT **184** may be connected to bars with configurations different than the bar **182** and in a different manner. For example, the slot **208** may receive the end of a straight bus bar that is oriented with its longitudinal axis extending in the direction of the Z-axis of the IDT **184**.

Referring now to FIGS. **16-21**, there is shown an IDC **220** for connecting a wire **16** to a bar **182** (such as a power busbar) that does not have holes formed therein. The IDC **220** includes an IDT **224** and a housing **14**. The IDT **224** is adapted for accommodating misalignment between the bar **182** and the IDT **224** when they are connected together. More specifically, the IDT **224** includes a coupler **225** for providing a connection to the bar **182**.

The IDT **224** includes a plurality of plates arranged in a stack **226**. The plates include a plurality of cutter plates **20***h* (shown best in FIG. **19**) disposed between outer holding plates **230**. The plates **20***h*, **230** may directly contact each other or be separated by a thin dielectric layer. Each cutter plate **20***h* has a contact projection **232** joined to and extending upward from the upper edge **27** of the base **26**. The contact projection **232** has a rectangular body **232***a* joined to an enlarged head **232***b* with an outer arcuate edge. As will be described more fully below, the contact projections **232** are connected to contact plates **234**, respectively.

Each of the contact plates **234** (also shown best in FIG. **19**) is a unitary or monolithic structure and is electrically conductive, being composed of a conductive metal, such as a tin plated copper alloy. Each contact plate **234** includes a pair of irregular-shaped elements or arms **236**, which have upper portions **236***a* and lower portions **236***b*, respectively. The arms **236** are joined together by a cross bar **240**, intermediate the upper and lower portions. The cross bar **240** extends laterally between the arms **236** and helps give the contact plate **234** a general H-shape. The upper portions **236***a* are separated by an upper spacing **242** and have nose-shaped projections **244**, respectively, that slope downwardly and inwardly to rounded interior ends. In this manner, the projections **244** provide the upper spacing **242** with a general V-shape entrance **242***a* and define a narrow inner gap **242***b* that adjoins the entrance **242***a*. The inner gap **242***b* connects the entrance **242***a* to an inner portion **242***c* of the upper spacing **242**. The lower portions **236***b* are separated by a lower spacing **248** and have inwardly-directed, bulbous protrusions **250**, respectively. The protrusions **250** narrow an entrance to the lower spacing **248**.

The holding plates **230** (shown best in FIG. **20**) have the same construction as the holding plates **24**, except the holding plates **230** each have a body **260** integrally and seamlessly joined to the upper edge **74** and extending upwardly therefrom. The bodies **260** each have a slot **262** formed therein, which extends through an upper free end **260***a* of the body **260**. Each slot **262** has an outer portion **262***a* that is V-shaped and a main portion **262***b* having a constant width. Although the slot outer portions **262***a* are aligned with the V-shaped entrances **242***a* of the upper spacings **242**, the slot outer portions **262***a* are wider in the Y-direction than the upper spacing entrances **242***a*.

Before the cutter plates **20***h* and the holding plates **230** are arranged together to form the stack **226**, the contact plates **234** are connected to the cutter plates **20***h*, respectively. More specifically, the contact projections **232** of the cutter plates **20***h* are inserted into the lower spacings **248** of the contact plates **234** by moving the contact projection bodies **232***a* in the stacking direction through the lower spacing entrances. With the cutter plates **20***h* and the contact plates **234** so arranged, the holding plates **230** are then secured to the cutter plates **20***h* by mechanical means and/or by welding, thereby preventing displacement of the contact plates **234** in the stacking direction. Since the contact projection heads **232***b* are too wide to pass through the lower spacing entrances of the contact plates **234**, the contact plates **234** are prevented from being displaced in the vertical (Z) direction. In this manner, the cutter plates **20***h* and the holding plates **230** cooperate to hold the contact plates **234** in place and thereby form the coupler **225**, i.e., the coupler **225** is formed by the contact plates **234**, the cutter plates **20***h* and the holding plates **230**. Although the contact plates **234** are held by the cutter plates **20***h* and the holding plates **239**, the contact plates **234** can still pivot about the contact projection heads **232***b*.

In the coupler **225**, the contact plates **234** are disposed with their planar surfaces adjoining each other, to form a stack **270**. The contact plates **234** are aligned with each other such that the upper spacings **242** form a first receiving slot **272** and the lower spacings **248** form a second receiving slot **274**. The first receiving slot **272** includes a V-shaped outer portion **272***a*. The first and second receiving slots **272**, **274** extend in the stacking direction, which is normal to the planar surfaces of the contact plates **234**. The number of contact plates **234** is equal to the number of cutter plates **20***h*; this number being determined by the amount of electrical current the coupler **225** (and the IDT **224**) are designed to handle, with the current carrying capacity of the coupler **225** (and the IDT **224**) being increased by increasing the number of contact plates **234** and cutter plates **20***h* that are used. Other factors that affect the current carrying capacity of the coupler **225** (and the IDT **224**) include the thickness of each contact plate **234** and each cutter plate **20***h*, the type of plating used and the composition of the underlying metal structure.

The cutter plates **20***h* and the holding plates **230** are arranged together in the stack **226** in a manner similar to the plates **20**, **24** in the stack **22** of the IDT **12** so as to provide the IDT **224** with a pair of legs **100** separated by a passage **102**. In addition, the contact projections **232** of the cutter plates **20***h* adjoin each other to form a laminated ridge **280**, which is disposed in the second receiving slot **274**, as best shown in FIG. **23**.

It is noted that with regard to the IDT **224**, the X-direction of the IDT **224** is the stacking direction of the cutter plates **20***h*, the Y-direction of the IDT **224** is the lateral direction (from leg **100** to leg **100**) and the Z-direction is the vertical direction, i.e., the direction in which the legs **100** extend.

The plates **20***h*, **230** are secured together in the stack **226** by mechanical means and/or by welding in the same manner as the plates **20**, **24** in the stack **22**, except, in the case of welding, for the absence of the upper welds **110**. Instead of having upper welds **110**, the stack **226** has upper welds **278** that extend across the tops of the shoulders **28**, **78** of the cutter plates **20***h* and holding plates **230**, respectively. As such, the upper welds **278** are disposed at the bottom of, and on opposing sides of, the laminated ridge **280**.

The electrical connection of the IDT **224** to the wire **16** in the housing **14** is the same as the IDT **12** described above. The IDT **224** may be electrically connected to the bar **182** by moving a blade portion **182***a* of the bar **182** vertically downward into the first receiving slot **272** through the outer portion **272***a*. As the blade portion **182***a* moves downward, the blade portion **182** contacts the interior ends of the projections **244** of the contact plates **234**, thereby deflecting them outward. The projections **244** maintain contact with the blade portion **182** after the blade portion **182***a* is fully disposed in the slot **272**, thereby establishing an electrical connection between the bar **182** and the coupler **225** and, thus, the IDT **224** and the wire **16**.

It should be appreciated that the IDT **224** may be connected to bars with configurations different than the bar **182** and in a different manner. For example, the first receiving slot **272** may receive the end of a straight bus bar that is oriented with its longitudinal axis extending in the direction of the Z-axis of the IDT **224**.

The provision of the IDT **224** with the coupler **225** permits some misalignment in the Y-direction between a bar and the first receiving slot. If the bar is offset from the inner gaps **242***b* of the contact plates **234** in the Y-direction when the bar is being moved downward (in the Z-direction) into the first receiving slot **272**, the bar will contact the sloping projections **244** of the contact plates **234**, which causes the contact plates **234** to pivot about the laminated ridge **280** (the X-axis) and guide the bar into the inner gap **242***b*. Even though the contact plates **234** pivot out of their normal position, they still maintain a good physical and electrical connection with the bar, thereby establishing a good physical and electrical connection between the bar and the IDT **224**.

It should be appreciated that in addition to accommodating misalignment in the Y-direction, the coupler **225** also accommodates misalignment in the X-direction and the Z-direction, as well as angular or twist misalignment in any of the three directions. The enlarged size of the slot outer portions **262***a* of the holding plates **230**, coupled with their alignment with the first receiving slot **272**, permits a bar to be offset in the X-direction vis-a-vis the first receiving slot **272** and still make a good physical and electrical connection with the contact plates **230**. In the Z-direction, the bar does not need to extend into the first receiving slot **272** to the full extent possible to make a good physical and electrical connection.

Another advantage provided by the coupler **225** is that it accommodates movement between parts that may occur after the parts have been connected. For example, the parts may move relative to each other due to environmental factors, such as temperature, vibration, impact or handling. The coupler **225** permits this relative movement, while still maintaining a good electrical and physical connection between the parts.

Referring now to FIGS. **22** and **23**, there is shown an IDT **290** for connecting a wire (such as wire **16**) to a female connector of an electrical/electronic device. Although not shown, the IDT **290** may be used with a housing **14**.

The IDT **290** has the same construction as the IDT **12**, except the IDT **290** has three cutter plates **20***e* (with no contact projections), a single holding plate **24** and a holding plate **292**. The holding plate **292** has the same construction as the holding plate **24**, except the holding plate **292** has a connector blade **294** that is seamlessly joined to the upper edge **74** and extends upward therefrom. The connector blade **294** has a tapered free end **296**.

The plates **20***e*, **24**, **292** are secured together in a stack **298** by mechanical means and/or welding in the same manner as the plates **20**, **24** in the stack **22**, except, in the case of welding, for the absence of the upper welds **110**. Instead of having upper welds **110**, the stack **298** has upper welds **300** that extend across the tops of the shoulders **28**, **78** of the cutter plates **20***e* and holding plates **24**, **292**, respectively.

The connector blade **294** may be used to connect to a female connector, such as a coupler **310** (shown in FIG. **24**) constructed in accordance with PCT Application No.: PCT/US17/47800, filed on Aug. 21, 2017 and entitled "ELECTRICAL CONNECTOR", which is hereby incorporated by reference in its entirety. The coupler **310** is comprised of a stack **312** of contact plates **314** disposed in a housing **316**. Each of the contact plates **314** is a unitary or monolithic structure and is electrically conductive, being composed of a conductive metal, such as a tin plated copper alloy. The contact plates **314** have a configuration similar to the contact plates **234**, i.e., are generally H-shaped. The contact plates **314** are disposed with their planar surfaces adjoining each other, to form the stack **312**. However, in other embodiments, the contact plates **314** may be separated by spaces, respectively. The contact plates **314** are aligned with each other so as to form a first receiving groove **342** and a second receiving groove.

The housing **316** is generally cuboid and is composed of an insulative material, such as plastic. The interior of the housing **316** is hollow and is sized to receive the stack **312** of contact plates **314** in a press fit operation, i.e., the interior is smaller in one or more dimensions than the stack **312**. The housing **316** includes opposing first side walls **354**, opposing second side walls **350** and opposing first and second open ends. The first side walls **354** each have a rectangular major slot **366** disposed toward the first open end and a rectangular minor slot **368** disposed toward the second open end.

The contact plates **314** are secured within the housing **16** in a press-fit operation in which the stack **312** as a whole is pressed into the housing **316** through the second open end **60**. The resulting interference fit between the stack **312** and the housing **16** secures the contact plates **314** within the housing **316**, but permits pivoting motion of the contact plates **314**. The first receiving groove **342** formed by the contact plates **234** is aligned with the major slot **366** of the housing **316**, while the second receiving groove formed by the contact plates **234** is aligned with the minor slot **368** of the housing **316**.

The connector blade **294** of the IDT **290** may, at least partially, be disposed in the first receiving groove **342** so as to be in electrical contact with the contact plates **314**. The connector blade **294** may be oriented such that a longitudinal edge of the connector blade **294** extends through the first receiving groove **342** and the major slot **366** of the housing **316**. Alternately, the connector blade **294** may be oriented such that the free end **296** of the connector blade **294** is received in the first receiving groove **342**, with the longitudinal axis of the connector blade **294** being disposed perpendicular to the first receiving groove **342**.

Referring now to FIGS. **25-26**, there is shown an IDT **320** for connecting a larger gauge wire **322**, such as a magnet wire, to a bus bar **324** (shown in FIGS. **31-33**) composed of a conductive metal, such as copper or a copper alloy. The wire **322** may have a diameter of 10 gauge or greater. The IDT **320** has a plurality of cutter plates **326** disposed between a pair of outer, holding plates **328**. The plates **326**, **328** are arranged in a stack in which they may directly contact each other or be separated by a thin dielectric layer. Each plate **326**, **328** has a monolithic unitary structure and is composed of electrically conductive metal, such as a copper alloy, which may or may not be plated with tin. The plates **326**, **328** may, by way of non-limiting example, be formed by stamping.

Referring now also to FIGS. **27-28**, each cutter plate **326** has opposing planar surfaces **329** and includes a base **330** having a lower portion with outwardly-extending, opposing flanges **332**. A pair of engagement legs **334** extend upwardly from the base **330** and are separated by a slot **336** defined by inner surfaces **337** of the engagement legs **334** and an inner surface of a rounded, closed end. The slot **336** is formed using chemical etching, which forms sharp edges **338** at the junctures between the inner surfaces **337** of the legs **334** and the planar surfaces **329**. In this manner, the inner surfaces **337** are generally concave in the direction between the surfaces **329**, as shown in FIG. **28**. The sharp edges **338** in each engagement leg **334** extend longitudinally along substantially the entire length of the engagement leg **334**. As will be described more fully below, the sharp edges **338** are operable to pierce an insulative coating on the wire **322**. The legs **334** have some elasticity so as to permit outward deflection.

The holding plates **328** have a construction generally similar to the cutter plates **326**. Each holding plate **328** includes a base **340** having a lower portion with outwardly-extending, opposing flanges **342**. A pair of legs **344** extend upwardly from the base **340** and are separated by a slot **346** defined by inner surfaces of the legs **344** and a rounded, closed end. Unlike the cutter plates **326**, however, the inner surfaces of the legs **344** do not have any sharp edges for removing the insulative coating from the wire **322**.

The holding plates **328** have a more rigid construction than the cutter plates **326**. In particular, the the holding plates **328** are more rigid than the cutter plates **326** in a lateral direction, i.e., in a direction normal to the direction of passage **347** formed by the cutter plates **326** and the holding plates **328** (described below). However, in an IDT **320'** constructed in accordance with another embodiment shown in FIG. **29**, holding plates **328'** may be provided with notches **349** that adjoin and extend downwardly from the slots **346**, respectively. The notches **349** give the holding plates **328'** some elasticity so as to be able to slightly deflect in the lateral direction when a wire is being disposed in the IDT **320'**.

The cutter plates **326** and the holding plates **328** are arranged in the stack so as to provide the IDT **320** with a base **348** (which is formed by the bases **330**, **340** of the cutter plates **326** and the holding plates **328**) and a pair of legs **350** (which are formed by the engagement legs **334** of the cutter plates **326** and the legs **344** of the holding plates **328**). The base **348** has outwardly-extending, opposing flanges **352** formed by the flanges **332**, **342** of the cutter plates **326** and the holding plates **328**. The legs **350** of the IDT **320** are separated by the passage **347** that is formed by the slots **336** in the cutter plates **326** and the slots **346** in the holding plates **328**. Inside the passage **347**, the inner surfaces **337** of the legs **334** of the cutter plates **326** adjoin each other so as to provide each leg **350** of the IDT **320** with a laminated, jagged inner surface **353**, with the sharp edges **338** forming a series of parallel sharp ridges arranged in the stacking direction of the cutter plates **326**.

The cutter plates **326** and the holding plates **328** are secured together in the stack by mechanical means and/or welding. The plates **326**, **328** may be mechanically held together by a bracket or a band in a press-fit manner. For example, a metal band may be tightly disposed around the IDT **320**, just above the base **348**, or the IDT **320** may be secured together (with or without welding) by a bracket. The plates **326**, **328** may be welded together by electron beam welding or laser beam welding. Welds are made on opposing sides of the base **348**. The legs **350** may be free from welds to permit independent movement of the engagement legs **334** of the cutter plates **326**.

Referring now to FIGS. **30-31**, the busbar **324** has a rectangular opening **354** configured to snugly receive the IDT **320** when the IDT **320** is pressed into the opening **354** from a bottom side of the busbar **324**. With the IDT **320** so positioned in the opening **354**, the flanges **352** of the IDT **320** are located on the bottom side of the busbar **324**, while the legs **344** and the passage **347** are located on the top side of the busbar **324**. Top surfaces of the flanges **352** abut a bottom surface of the busbar **324**, around the opening **354**. The base **348** of the IDT **320** is secured to the busbar **324** around the opening **354** by electron beam welding or laser beam welding.

Referring now to FIG. **32**, there is shown a plurality of magnet wires **322** wound around a magnet core **356**. End portions of the wires **322** are secured to busbars **324** by IDTs **320**, respectively. The end portion of each wire **322** is pressed into the passage **347** of its respective IDT **320**, which causes the jagged inner surfaces **353** of the legs **350** to strip off any insulative coating on the wire **322**, thereby making a good electrical connection between the wire **322** and the IDT **320**. In each IDT **320**, the elasticity of the legs **334** of the cutter plates **326** maintain a high normal force on the wire **322** in the event of wire creep. The welded construction of the IDT **320**, together with the holding plates **328**, provide the IDT **320** with structural rigidity that resists motion of the wire **322**.

Referring now to FIGS. **33-38**, there is shown an IDT **360** having a low profile. The IDT **360** has a plurality of cutter plates **362** secured between a pair of outer, holding plates **364**. The plates **362**, **364** are arranged in a stack in which they may directly contact each other or be separated by thin dielectric layers. Each plate **362**, **364** has a monolithic unitary structure and is composed of electrically conductive metal, such as a copper alloy, which may or may not be plated with tin. The plates **362**, **364** may, by way of non-limiting example, be formed by stamping.

Each cutter plate **362** includes a base **366** having a pair of engagement legs **370** extending in a first direction therefrom. A top edge surface **371** of the base **366** extends uninterrupted between opposing sides of the cutter plate **362**. In some embodiments, however, one or more contact projections (not shown) may extend from the top edge surface **371** of the base **366** in a second direction, which is opposite the first direction. In these embodiments, each contact projection is adapted for making an electrical connection with an electrical/electronic device (such as a PCB) and may, by way of non-limiting example, be a press-fit contact projection **34**, such as is shown in FIGS. **1-3**, **5**, and **9**). Alternately, the contact projection may be a pin for soldering in a hole of a PCB, or a weld tab **36**, as shown in FIG. **4**, or may have some other type of construction, such as the contact projection **192** shown in FIG. **13** or the contact projection **232** shown in FIG. **19**. If one or more of the cutter plates **362** of the IDT **360** is provided with a contact projection, the number and arrangement of the contact projection(s) may be as described above with regard to the IDT **12**.

Each engagement leg **370** of a cutter plate **362** has an upper portion joined to the base **366** and a lower portion forming a free end. The engagement legs **370** are spaced-apart to form a slot **374** therebetween. The slot **374** has a closed end, located toward the base **366**, and an open end, located at the free ends. The slot **374** is defined by opposing inner side surfaces **376** of the engagement legs **370**, respectively, and has a holding portion **374***a*. Upper portions of the inner side surfaces **376** have a slight convex curvature such that the holding portion **374***a* is most narrow at a point about midway along the length of the holding portion **374***a*.

Each engagement leg **370** has an opening **378** extending therethrough, which helps form a flexible portion **380** in each engagement leg **370**. The opening **378** is generally elliptical and is defined by a continuous interior surface **382** of the engagement leg **370**. A portion of the interior surface **382** located toward the slot **374** is concave and has a center of curvature that corresponds to the narrowest portion of the holding portion **374***a*. The concave portion of the interior surface **382** and the convex portion of the inner side surface **376** help define the flexible portion **380** and provide it with an inwardly-bowed configuration.

The configuration of the flexible portions **380** makes them elastic, but with a high degree stiffness, which enables the flexible portions **380** to store enough force to maintain an acceptable contact force on the conductor of a wire (such as the wire **16**) disposed in the holding portion **374***a*, even when the cross-section of the conductor of the wire **16** decreases due to mechanical creep. As such the flexible portions **380** function as springs to generate a high normal force connection to the conductor of the wire **16**.

Each engagement leg **370** has an irregular outer side surface **388** with a lower portion that slopes inwardly toward the free end. Toward the base **366**, the outer side surface **388** projects outwardly and then inwardly to form a barb **390**. An outside notch **392** is formed proximate to the barb **390**.

Inside notches **394** are formed in the engagement legs **370**, toward the free ends, respectively. The inside notches **394** are arcuate and are defined by curved portions of the inner side surfaces **376**, respectively, which adjoin the convex portions of the inner side surfaces **376** at sharp corner edges **398**, respectively. The sharp edges **398** extend in the direction of the thickness of the cutter plate **362** and function as scrapers and/or cutters for piercing the insulation layer of a wire (such as the wire **16**) and are hereinafter referred to as cutters **398**. Below the inside notches **394**, the inner side surfaces **376** slope outwardly to the free ends, respectively.

The holding plates **364** have a construction generally similar to the cutter plates **370**. Unlike the cutter plates **370**, however, the holding plates **364** do not have any cutters or scrapers for removing the insulation layer from the wire **16**. In addition, the holding plates **364** are typically thicker than the cutter plates **370**. The holding plates **364** each have a monolithic unitary structure and are composed of electrically conductive metal, such as a copper alloy, which may or may not be plated with tin. The holding plates **364** may, by way of non-limiting example, be formed by stamping. Each holding plate **364** includes a base **400** having a smooth, planar upper edge surface **402** extending, uninterrupted, between opposing sides of the holding plate **364**. A pair of legs **404** extend from the base **400** in a first (downward) direction. In some embodiments, one or more contact projections may extend from the upper edge surface **402** of the base **400** in a second direction, which is opposite the first direction.

Each leg **404** of the holding plates **364** has an upper portion joined to the base **400** and a lower portion forming a free end. The legs **404** are spaced-apart to form a slot **412** therebetween. The slot **412** has an arcuate, closed end, located toward the base **400**, and an open end, located at the free ends. The legs **404** each have a smooth inner side surface **414** and an irregular outer side surface **416** with a lower portion that slopes inwardly toward the free end. Toward the base **400**, the outer side surface **416** projects outwardly and then inwardly to form a barb **418**. An outside notch **420** is formed proximate to the barb **418**. The slot **412** is defined by the inner side surfaces **414** of the legs **404**.

The cutter plates **362** and the holding plates **364** are secured together in a stack by mechanical means and/or welding to provide the IDT **360** with a base **420** (which is formed by the bases **366**, **400** of the cutter plates **362** and the holding plates **364**) and a pair of legs **424** (which are formed by the engagement legs **370** of the cutter plates **362** and the legs **404** of the holding plates **364**). The cutter plates **362** and the holding plates **364** may be secured together by a band or welded together in the manner described above with regard to IDT **12**. Each leg **404** has an outer boundary delimited by the outer side surfaces **388**, **416** of the cutter plates **362** and the holding plates **364**, respectively, and and an inner boundary delimited by the inner side surfaces **376**, **414** of the cutter plates **362** and the holding plates **364**, respectively.

The legs **424** of the IDT **360** are separated by a passage **430** that is formed by the slots **374** in the cutter plates **362** and the slots **412** in the holding plates **364**. The holding portions **374***a* of the cutter plates **362** are aligned with each other to form a holding portion **430***a* of the passage **430**, which is disposed inward from the upper portions of the inner side surfaces **376** of each of the holding plates **364**. The cutters **398** in each of the legs **404** are aligned to form a laminated cutting edge **434** disposed in the passage **430**.

On the outer side of each leg **424**, the barbs **390**, **418** of the cutter plates **362** and the holding plates **364**, respectively, are aligned and form a laminated barb **435** having a top ledge **436**. The outside notches **392**, **420** of the cutter plates **362** and the holding plates **364**, respectively, are also aligned and form a groove **438** that adjoins the top ledge **436** of the barb **435**. The cutter plates **362** and the holding plates **364** may be mechanically secured together by a metal band that is tightly disposed around the stack, just below the ledges **436**. Alternately, the cutter plates **362** and the holding plates **364** may be mechanically secured together by the bracket **446** described below.

The IDT **360** is shorter (has a lower profile) than the IDT **12** for a particular application because of the construction of the engagement legs **370** of the cutter plates **362**. In particular, the flexible portion **380** of an engagement leg **370** provides the same normal force to a wire conductor as the entire engagement leg **32** of a cutter plate **20** of the IDT **12**. As such, the engagement legs **370** of the IDT **360** can be made shorter than the engagement legs **32** of the IDT **12**.

With particular reference now to FIGS. **35** and **36**, the IDT **360** may be used with a housing **440**. The housing **440** has the same construction as the housing **14** of the IDC **10**, except the housing **440** is shorter, i.e., has a lower profile, than the housing **14** to accommodate the lower profile of the IDT **360**. The IDT **360** and the housing **440** may be engaged with each other in substantially the same manner as the IDT **12** and the housing **14** to make an electrical connection between a wire (such as the wire **16**) and the IDT **360**. One difference is that the laminated barbs **435** exert forces against the interior side surfaces of the housing **440** to retain the IDT **360** in the pocket of the housing **440**. In contrast, the barbs **92** of the holding plates **24** of the IDT **12** engage the interior side surfaces of the housing **14** to retain the IDT **12** in the housing **14**.

With particular reference now to FIGS. **37** and **38**, there is shown a mounting bracket **446** that may be used to mount the IDT **360** to a pad of an electrical/electronic device, such as a printed circuit board or a metal core printed circuit board. The bracket **446** generally has the configuration of a C-shaped clip and is formed from an electrically conductive metal, such as a copper alloy, which may or may not be plated with tin. The bracket **446** includes a frame **448** connected to a mounting plate **450** by a pair of bends **452** such that the frame **448** is disposed parallel to, but spaced from, the mounting plate **450**. The frame **448** includes an enlarged opening **454** that is configured to snugly receive the base **420** of the IDT **360**. To mount the IDT **360** to the bracket **446**, the base **420** is inserted into the opening **454** until the top ledges **436** of the barbs **435** contact portions of the frame **448** disposed adjacent to the opening **454**. In this manner, the frame **448** holds and supports the IDT **360** in position relative to the rest of the bracket **446**. With the IDT **360** so mounted, the IDT **360** is physically and electrically connected to the bracket **446**.

The IDT **360** in combination with the bracket **446** and/or the housing **440** may form an IDC that is operable to electrically connect an insulated wire, such as the wire **16**, to an electrical/electronic device, such as a PCB. As can be readily appreciated, the bracket **446** is not used in those embodiments where the IDT **360** has one or more contact projections adapted for making an electrical connection with an electrical/electronic device. FIGS. **39-43** show some of the applications in which the IDT **360** may be used.

FIG. **39** shows a plurality of IDTs **360** mounted to brackets **446**, respectively. A plurality of the brackets **446** (with IDTs **360**) are secured to metal pads **460** of an electrical/electronic device **462**, which may be a PCB or a metal core printed circuit board having electronic components mounted thereto. The brackets **446** are secured to the pads **460** by soldering or sintering the outer sides of the mounting plates **450** of the brackets **446** to the pads **460**, respectively. The IDTs **360** mounted to the brackets **446** secured to the metal pads **460** are physically and electrically connected to the device **462**.

As shown in FIG. **40**, the device **462** may be a component of a larger device or machine **464**, such as an electric motor. The device **462** is mounted to the underside of an end piece **466** of the machine **464**. The legs **424** of the IDTs **360** extend downwardly from the device **462** and are securely received within housings **440**, which are secured to another component **468** (such as a PCB) of the machine **464**. The housings **440**, in turn, hold wires (such as the wires **16**). With the IDTs **360** so connected to the housings **440**, the IDTs **360** (and, thus, the device **462**) are electrically connected to the wires **16** (and, thus, the component **468**). In this particular application, a plurality of IDCs are formed, with each IDC comprising an IDT **360**, a bracket **446** and a housing **440**.

Referring now to FIG. **41**, a first pair of IDTs **360** mounted in brackets **446**, respectively, are electrically connected to wires **470** of a first electrical device **472**, such as a magnetic coil, and a second pair of IDTs **360** mounted in brackets **446**, respectively, are electrically connected to wires **474** of a second electrical device **476**, such as a coil, which may also be magnetic. The first and second pairs of IDTs **360** and brackets **446** extend through openings in a substrate **480**, such as that of a PCB, which may, at least partially, support the electrical devices **472**, **476**. The brackets **446** may be electrically and physically connected to a structure of the substrate **480** or to a structure disposed below the substrate **480**. In this particular application, a plurality of IDCs are formed, with each IDC comprising an IDT **360** and a bracket **446**.

Referring now to FIG. **42**, electrical devices **482**, **486** are shown mounted to a support housing **492**. The support housing **492** is composed of plastic and supports coils of the electrical devices **482**, **486**. The support housing **492** includes a plurality of the housings **440** within which IDTs **360** are mounted to form a plurality of IDCs. The housings **440** may be integrally joined together, e.g., are molded into the support housing **482** to form a monolithic structure. The IDCs hold wires **494**, **496** of the electrical devices **482**, **486**. A plurality of the housings **440** are integrally joined to snap-fit projections **498** for securing the support housing **492** to a substrate, such as a PCB in a snap-fit manner. It should be appreciated that in other embodiments, a pair of support housings may be provided, one for each of the electrical devices **482**, **486**. Still further, the support housing **492** may including a plurality of sections that are not integrally joined together, but are interconnected.

The IDT **360** is described above as being used with the housing **440** or the bracket **446** to electrically connect an insulated wire to an electrical/electronic device, such as a PCB. It should be appreciated, however, that the IDT **360** by itself may be used to electrically connect a wire to an electrical/electronic device. For example, a top surface of the IDT **360** formed from the top edge surfaces **371** of the cutter plates **362** and the upper edge surfaces **402** of the holding plates **364** may be directly secured (such as by soldering or sintering) to a metal pad of a PCB. Alternately, the IDT **360** may be modified to include a metal plate that is secured (such as by welding) directly to the top edge surfaces **371** of the cutter plates **362** and the upper edge surfaces **402** of the holding plates **364**. This metal plate would then be secured to the metal pad of the PCB through soldering or sintering. In these examples, the IDT **360** alone would form an IDC.

The IDTs of the present disclosure may be produced in a roll-to-roll assembly process, wherein a plurality of the IDTs are formed on a continuous strip of metal that also forms part of the IDTs. FIG. **43** shows a plurality of IDTs **12** that have been so formed and FIG. **44** shows a plurality of IDTs **172** that have been so formed. For purposes of brevity, the process will only be described with regard to the IDT **12**, it being understood that the process is essentially the same for each different type of IDT.

The process uses a continuous strip **560** of metal (such as a copper alloy) that is stamped to form a plurality of bottom holding plates **24** that are connected together by spacers **562** joined between the shoulders **78** of the holding plates **24**. The strip **560** has notches or scores **564** formed therein at the junctures between the spacers **562** and the shoulders **78** to facilitate the separation of the formed IDTs **12**. Cutter plates

20 and a top holding plate 24 are stacked on top of each holding plate 24 of the strip 560 and are then secured together to form an IDT 12. The strip 560 may be fully stamped to form all of the bottom holding plates 24 before the cutter plates 20 and the top holding plates 24 are stacked and secured on the strip 560, or the strip 560 may be stamped as the cutter plates 20 and the top holding plates 24 are stacked and secured to the strip 560. The stacking and securing of the cutter plates 20 and the top holding plate 24 to form an IDT 12 may be performed at a single station, with the strip 560 moving into and out of the station to form an IDT 12 on the strip 560. If the strip is not fully stamped ahead of time, the strip 560 may be stamped to form the bottom holding plate 24 at the same station or at another, previous station. Alternately, the stacking and securing of the plates 20, 24 may be performed at a plurality of stations, with the strip 560 being moved from station to station to form an IDT 12. If the strip 560 is not fully stamped ahead of time, the strip 560 may be stamped to form the bottom holding plate 24 at an initial station before the strip moves to the other stations. In one example, there may be six stations, one for the stamping to form the bottom holding plate 24, one for placement of each cutter plate 20, one for placement of the top holding plate 24 and one for securing the plates together.

The process of forming the IDTs 12 described above may further include the step of separating the IDTs 12 at the scores to form a plurality of separate IDTs 12, which are then packaged for shipment and/or sale. Alternately, the IDTs 12 may be kept together on the strip 560 and packaged for shipment and/or sale as a strip of interconnected IDTs 12.

While each of the IDTs and IDCs described above is described as having structure for displacing/removing insulation from a wire and being used for this function, it should be appreciated that the IDTs and IDCs described above can be used with wires that have already had insulation removed so as to expose the underlying conductor. In such an application, the exposed conductor of the wire moves into the holding portion (102*a*, 430*a*) of the passage (102, 430) in an IDT with only a small amount of scraping against the laminated cutting edges (108, 434) and is held in the holding portion (102*a*, 430*a*) by the high normal forces exerted by the resilient engagement legs (32, 370) of the cutter plates (20, 362).

It should also be appreciated that the above-described IDTs can be modified so as to be especially adapted for use with wires that have already had insulation removed. For example, the cutters (62, 398) of the cutter plates (20, 362) in an IDT may be removed and replaced with rounded edges. The curvature of the edges may be selected to provide a gradual or more abrupt transition from the entrance portion to the holding portion (102*a*, 430*a*) depending on the nature of the conductor, etc.

It is to be understood that the description of the foregoing exemplary embodiment(s) is (are) intended to be only illustrative, rather than exhaustive. Those of ordinary skill will be able to make certain additions, deletions, and/or modifications to the embodiment(s) of the disclosed subject matter without departing from the spirit of the disclosure or its scope.

What is claimed is:

1. An insulation displacement connector for making an electrical connection to at least one wire having an inner metal conductor covered with an outer insulation layer, the insulation displacement connector comprising:

a plurality of metal plates secured together to form a stack that defines a passage for receiving the wire,

wherein a plurality of the plates are cutter plates having cutting edges, respectively, for disrupting the insulation layer of the wire to permit the conductor to directly contact the cutter plates, each of the cutter plates comprising a pair of legs joined to a base, each of the legs including one of the cutting edges and being spaced-apart to form a slot in-between, the cutting edges adjoining the slot on opposing sides of the slot;

wherein an outermost pair of the plates are holding plates, each holding plate comprising a pair of legs that are spaced-apart to form a slot in-between, the cutter plates being disposed between the holding plates such that the slots in the cutter plates and the holding plates are aligned to form the passage; and

wherein the holding plates are more rigid than the cutter plates in a direction normal to the direction of the passage.

2. The insulation displacement connector of claim 1, wherein in each cutter plate, each leg has a hole extending therethrough that forms a spring portion that is resiliently deflectable in a direction normal to the direction of the passage.

3. The insulation displacement connector of claim 1, further comprising:

a housing having a pair of opposing side walls with slots formed therein and an interior pocket accessible through an exterior opening in the housing, the pocket being adapted to receive at least a portion of the stack and being at least partially defined by opposing interior surfaces, the slots being aligned and cooperating with the pocket to form a route extending through the housing, the route being adapted to receive the wire and being aligned with the passage in the stack when the stack is disposed in the pocket.

4. The insulation displacement connector of claim 3, wherein each of the holding plates have outer edges with barbs for engaging the interior surfaces of the housing.

5. The insulation displacement connector of claim 1, further comprising:

a bracket having a frame connected to and spaced from a mounting plate, the frame defining an opening through which at least a portion of the stack extends.

6. The insulation displacement connector of claim 5, wherein the frame is connected by one or more bends to the mounting plate, and wherein the frame is disposed parallel to the mounting plate.

7. The insulation displacement connector of claim 1, wherein at least one of the cutter plates has a contact projection for making an electrical connection.

8. The insulation displacement connector of claim 7, wherein the contact projection comprises a fastening structure that is resiliently deformable for press-fit insertion into a hole of a substrate.

9. The insulation displacement connector of claim 1, wherein the stack is for electrically connecting the wire, which is a first wire, to a second wire having an inner metal conductor covered with an outer insulation layer;

wherein the stack defines a second passage for receiving the second wire; and

wherein at least one of the plates has an additional two cutting edges for disrupting the insulation layer of the second wire to permit the conductor of the second wire to directly contact the plate.

10. A combination of a plurality of the insulation displacement connectors of claim 1, wherein the insulation displacement connectors are secured together.

11. The combination of claim 10, wherein in each of the insulation displacement connectors, the holding plates are first and second holding plates and wherein the first holding plates are connected together by spacers, and wherein the first holding plates and the spacers are together a monolithic structure formed from a single metal strip, and wherein the spacers are delimited by scores that facilitate the separation of the stacks from each other,

wherein the cutter plates are disposed between the holding plates; and

wherein the slots in the cutter plates and the holding plates are aligned to form the passage.

12. The insulation displacement connector of claim 1, wherein the holding plates do not have any cutting edges, and wherein the holding plates and the cutter plates are monolithic structures.

13. The insulation displacement connector of claim 7, wherein a plurality of the cutter plates have contact projections, respectively, for making electrical connections.

14. The insulation displacement connector of claim 13, wherein the cutter plates and the holding plates are secured together by welding.

15. The insulation displacement connector of claim 13, wherein each of the contact projections of the cutter plates comprise a pair of tines separated by a spacing, the spacings being aligned so as to form a slot for receiving a bar.

16. The insulation displacement connector of claim 15, wherein the tines of the cutter plates are not secured together and are resiliently deflectable; and wherein the holding plates each have a body portion with a slot formed therein, the tines being disposed between the body portions of the holding plates such that the slots of the holding plates are aligned with the slot formed by the tines of the cutter plates.

17. The insulation displacement connector of claim 13, wherein the insulation displacement connector is adapted for mounting to a substrate;

wherein each of the cutter plates has a contact projection with a fastening structure that is resiliently deformable for press-fit insertion into a hole of the substrate; and

wherein each of the holding plates has an upwardly-extending tongue with a tapered free end for receipt into a slot of the substrate.

18. The insulation displacement connector of claim 13, further comprising a plurality of contact plates connected to the cutter plates, respectively; and

wherein each of the contact plates comprise a pair of arms separated by a spacing, the spacings being aligned so as to form a slot for receiving a bar.

19. The insulation displacement connector of claim 18, wherein the contact plates are pivotable about the contact projections of the cutter plates, respectively; and

wherein the contact projections of the cutter plates have an arcuate surface to facilitate pivoting.

20. The insulation displacement connector of claim 18, wherein in each contact plate, the spacing is an upper spacing and wherein each contact plate further has a lower spacing, the arms of each contact plate being joined together in-between the upper and lower spacings;

wherein the contact plates are arranged in a stack such that the upper spacings of the contact plates form the slot, which is an upper slot, and the lower spacings of the contact plates form a lower slot; and

wherein the contact projections of the cutter plates form a laminated ridge which is disposed in the lower slot formed by the contact plates, whereby the contact plates are pivotable about the laminated ridge.

21. The insulation displacement connector of claim 20, wherein the holding plates each have a body portion with a slot formed therein, the contact plates being disposed between the body portions of the holding plates such that the slots of the holding plates are aligned with the upper slot of the contact plates; and

wherein the contact projections of the cutter plates prevent the contact plates from being removed in a vertical direction and the holding plates prevent the contact plates from being removed in a stacking direction, whereby the cutter plates and the holding plates pivotably hold the contact plates to thereby form a coupler.

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